INTERAVIA

REVIEW OF WORLD AVIATION

IN THIS ISSUE

Reshaping the Air Arm

Trends in Electronics

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VOLUME XI

10

OCTOBER 1956

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INTERAVIA

Review of World Aviation

Volume XI No. 10 October 1956

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Front cover:

A radio telescope with a reflector 82 ft. in diameter has been set up on Stockert Hill, near Münstereifel, under contract to the North Rhine-Westphalia Ministry of Economy and Transport. Designed initially for recording electro-magnetic radiation from the universe, it is later to be used also for basic radar research. The installation was built under the technical supervision of the firm of Telefunken.

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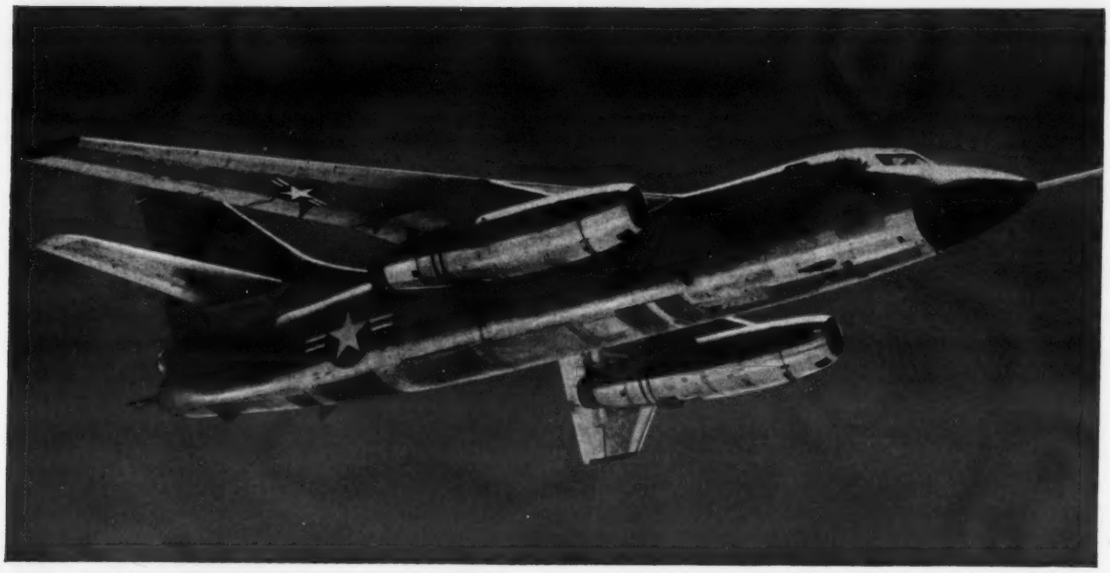
Flying time cut by half
By 1959 four Boeing jet Stratoliners will place New York within 6 hrs. 40 mins. and Leopoldville within 7 hrs. 50 mins. of Brussels.
All 3 equipped with R.C.A. NOSE RADAR which sees the route up to 150 miles ahead

"EYES" FOR THE AIR FORCE TACTICAL AIR COMMAND



Air Force RB-66 powered by Allison J71 Turbo-Jet Engines

ALLISON
TURBO-JET
AND TURBO-PROP POWER

Here you see the Tactical Air Command's newest reconnaissance bomber—the all-weather twin-jet Douglas RB-66.

It carries a payload of nuclear or conventional bombs—which it can wing at 600-700 mph to targets dictated by the nation's needs.

It packs a full complement of camera equipment —which also makes it a valuable reconnaissance tool for air intelligence.

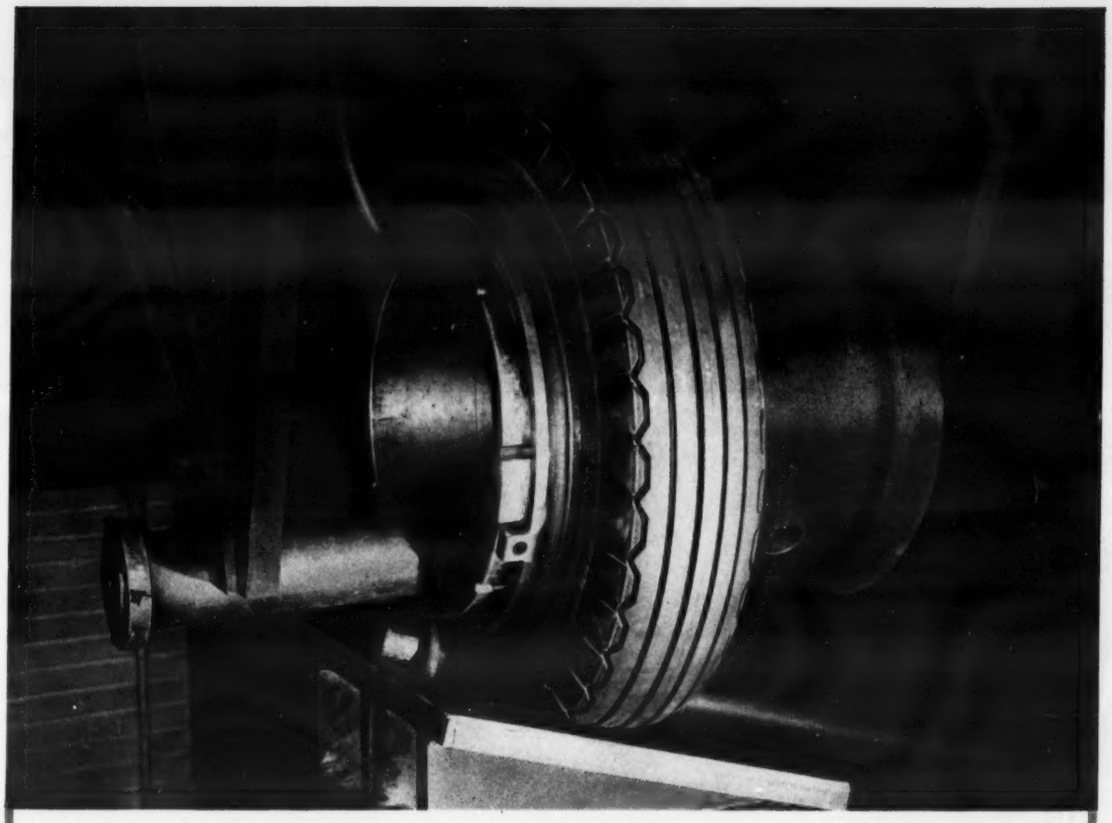
And in pods under its wings it boasts a pair of Allison J71 Turbo-Jet engines — each producing 10,000 pounds' thrust without augmentation — which take it to altitudes over 40,000 feet.

Now winning its wings for reliability and dependability with the 363rd Tactical Reconnaissance Wing at Shaw Air Force Base, S. C., the Allison-powered RB-66 carries a three-man crew as it goes on its peace-maintaining missions.

The Allison-powered Douglas RB-66 is another example of how continuous engine development —both Turbo-Jet and Turbo-Prop—is helping keep America first in the air.

ALLISON DIVISION OF GENERAL MOTORS, Indianapolis, Indiana

AMERICAN BUILT FOR THE JET ERA IN AIR TRAVEL



Picture of a tubeless airplane tire making a "landing" on the deck of an aircraft carrier

The above picture is a Goodyear laboratory test which duplicates the stresses encountered when a tubeless tire makes a landing on an aircraft carrier. In this case, the tire is subjected to a 45,000-pound radial loading and a 14,200-pound side loading—simulating the punishment which might result when a plane strikes a carrier deck for a landing with one wing up 17° from horizontal norm on a small 24" diameter tire.

To make the test even tougher and more precise, note that Goodyear has laid a 1⅜" bar across the loading platform—duplicating actual landing conditions where a tire smacks across an arresting cable.

In addition to all this, Goodyear required the tire to contain pressures ranging up to 350 pounds per square inch!

Through such investments in exhaustive research and test equipment, Goodyear earns and maintains a world-wide leadership—not only in tire building, but in the engineering of aircraft wheels and brakes as well.

Proof: *More aircraft land on Goodyear Tires, Wheels and Brakes than on any other make!*

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Strategic Air Command ground crewman directs Boeing B-52 bomber into flight-line position at Castle Air Force Base, California.

Two of the eight J-57 jet engines that power the B-52. Suspended in pairs, the engines deliver more than 10,000 pounds of thrust each.

B-52 tail towers nearly five stories above ground. Rear tip of fuselage contains armament and fire controls.

America's jet bomber wings go global with B-52s

The nation's defense program is taking giant strides forward as wings of the Strategic Air Command continue the transition to Boeing B-52 Stratofortresses.

First SAC unit to complete the switch to intercontinental B-52s was the 93rd Heavy Bomb Wing, at Castle Air Force Base, California, where the pictures on this page were taken. Another unit – the 42nd Heavy Bomb Wing at Loring Air Force Base, Maine – is now being equipped with B-52s.

Along with Boeing B-47 medium jet bombers, the B-52 heavy jet bombers are kept in combat readiness day and night by dedicated Strategic Air Command crews. Together they constitute the most potent deterrent against aggression now in existence.

BOEING

Side view of intercontinental B-52. This fleet, swept-wing giant is capable of speeds beyond 650 miles an hour, and altitudes above 10 miles.

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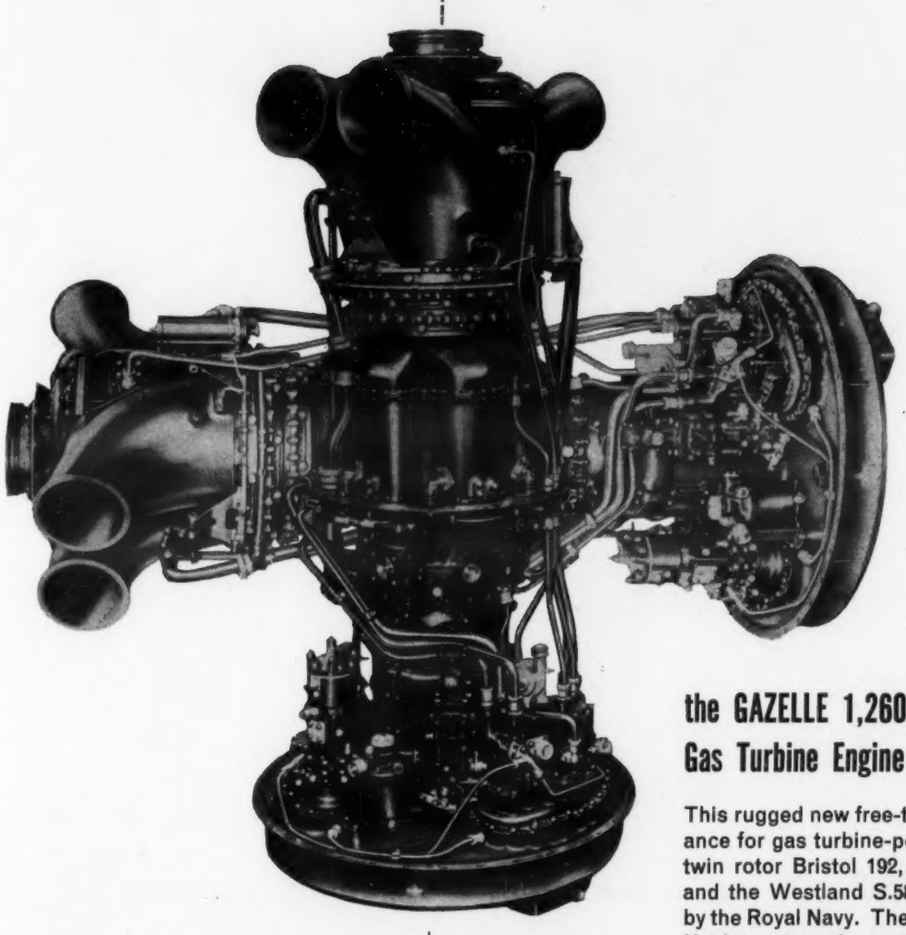

the GAZELLE 1,260-2,000 s.h.p. Gas Turbine Engine

This rugged new free-turbine engine of notable performance for gas turbine-powered helicopters will power the twin rotor Bristol 192, adopted by the Royal Air Force and the Westland S.58 " Wessex " helicopter, adopted by the Royal Navy. The engine embodies the safe, simple Napier automatic control system.

For ease of installation it can be mounted in any position between the vertical and horizontal.

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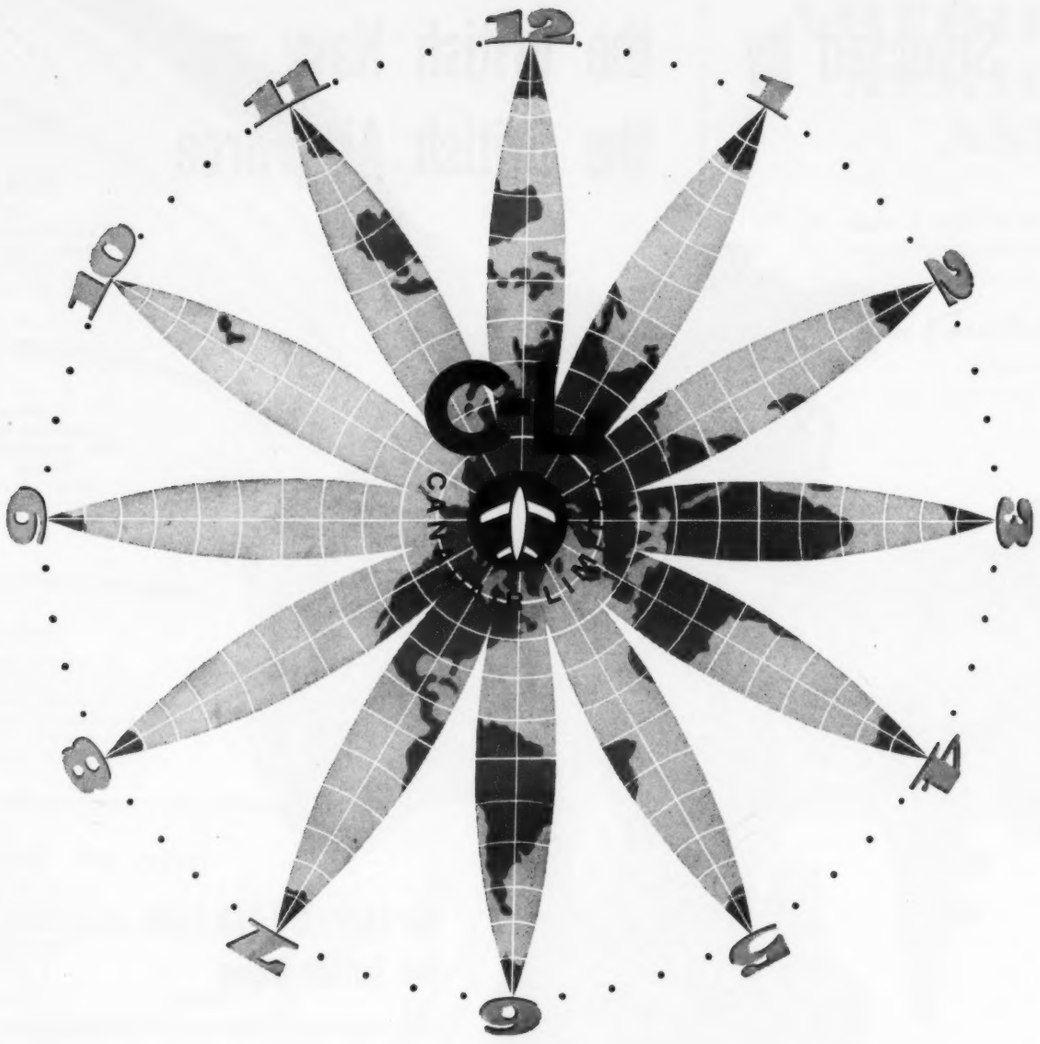

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with maximum safety
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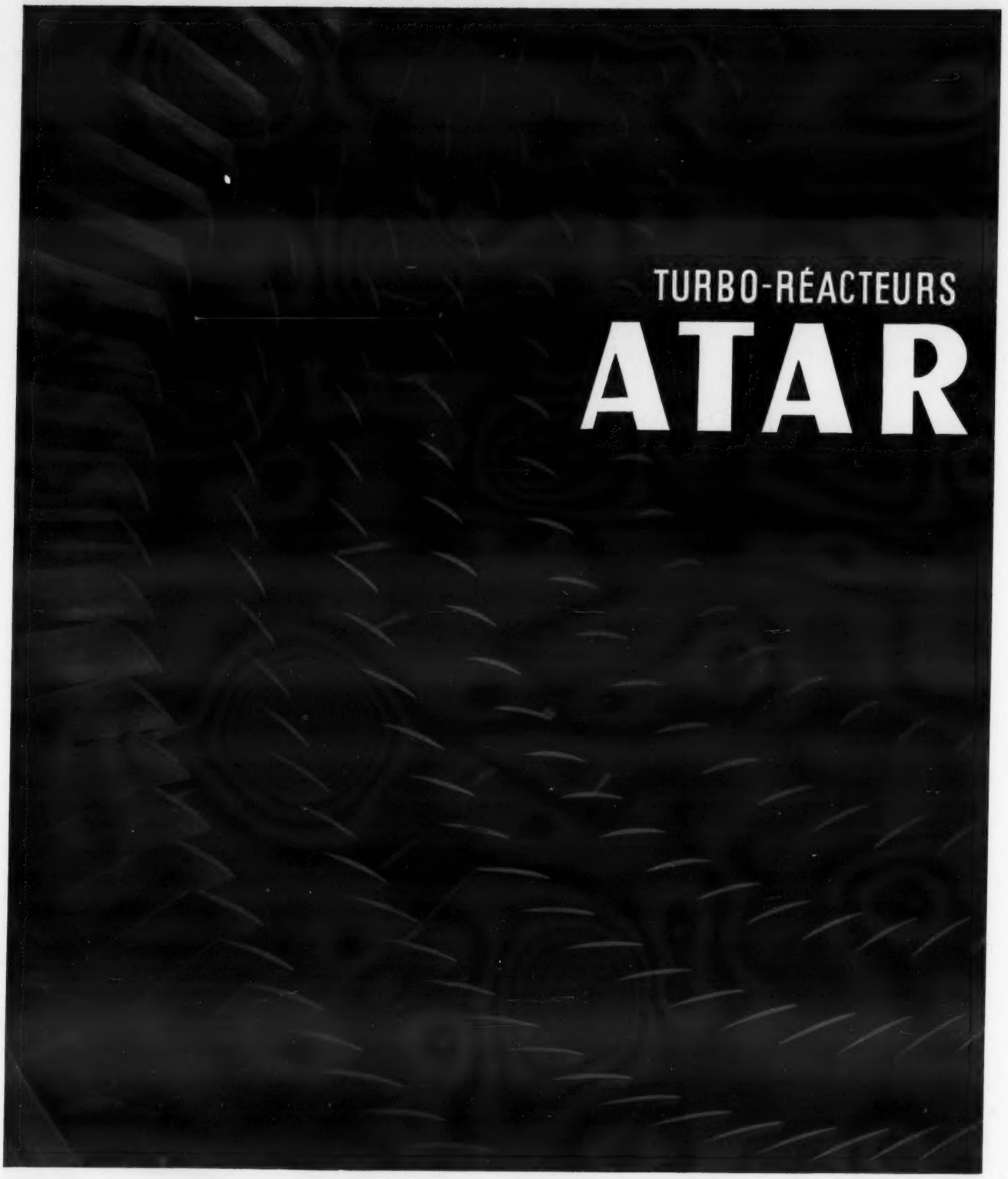

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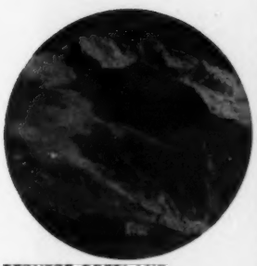

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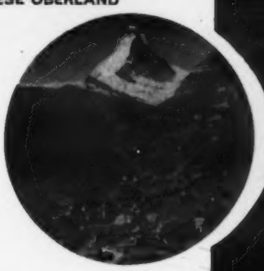

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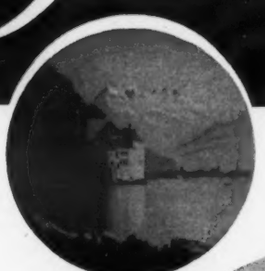

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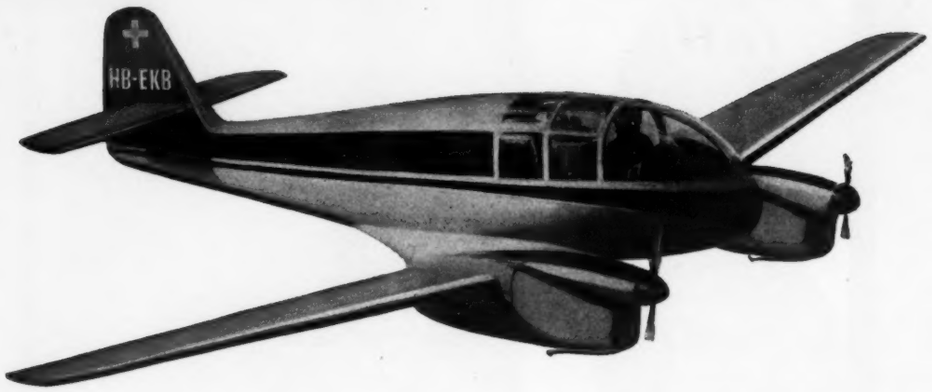

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Personally speaking

—a series of contributions on questions of the hour by leading aviation personalities.

GERHARD HÖLTJE

Technical Director of Deutsche Lufthansa and one of the men most concerned in the reconstruction of German Civil Aviation, makes this contribution on the . . .

Problems of building up an airline

We are only in the early stages of development. The unwelcome effects of the 10-years' break make themselves felt everywhere, particularly where air crews are concerned. In spite of their own personnel difficulties, BEA and TWA have lent us several of their best pilots until our own air crews are properly trained and have enough experience to master unassisted the duties imposed by modern air traffic. The new German Civil Pilots School will be responsible for training the necessary reserve of pilots.

The limited size of our fleet has hindered us in developing our routes, which will be extended to about 26,500 km. by the end of 1956. We have now ordered 7 Vickers Viscounts and, like other airlines, we expect to put our first jet aircraft into international service in about 1960.

I have had the greatest pleasure and satisfaction from the fact that when Lufthansa reappeared in international aviation we were welcomed as an equal by the other airlines, who offered us their support without prejudice or selfishness. This showed a corporate spirit which alone can overcome the international problems of Civil Aviation.

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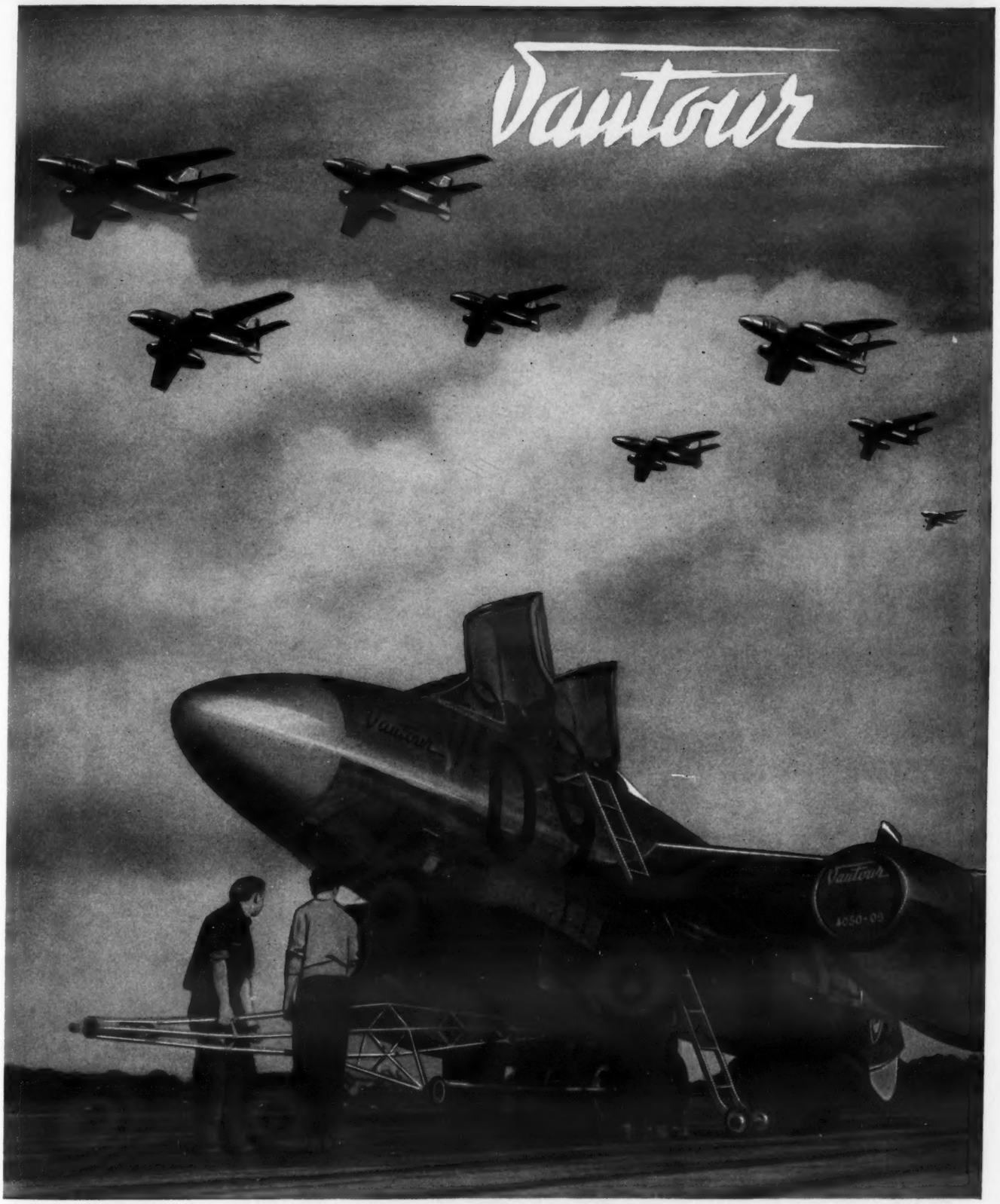

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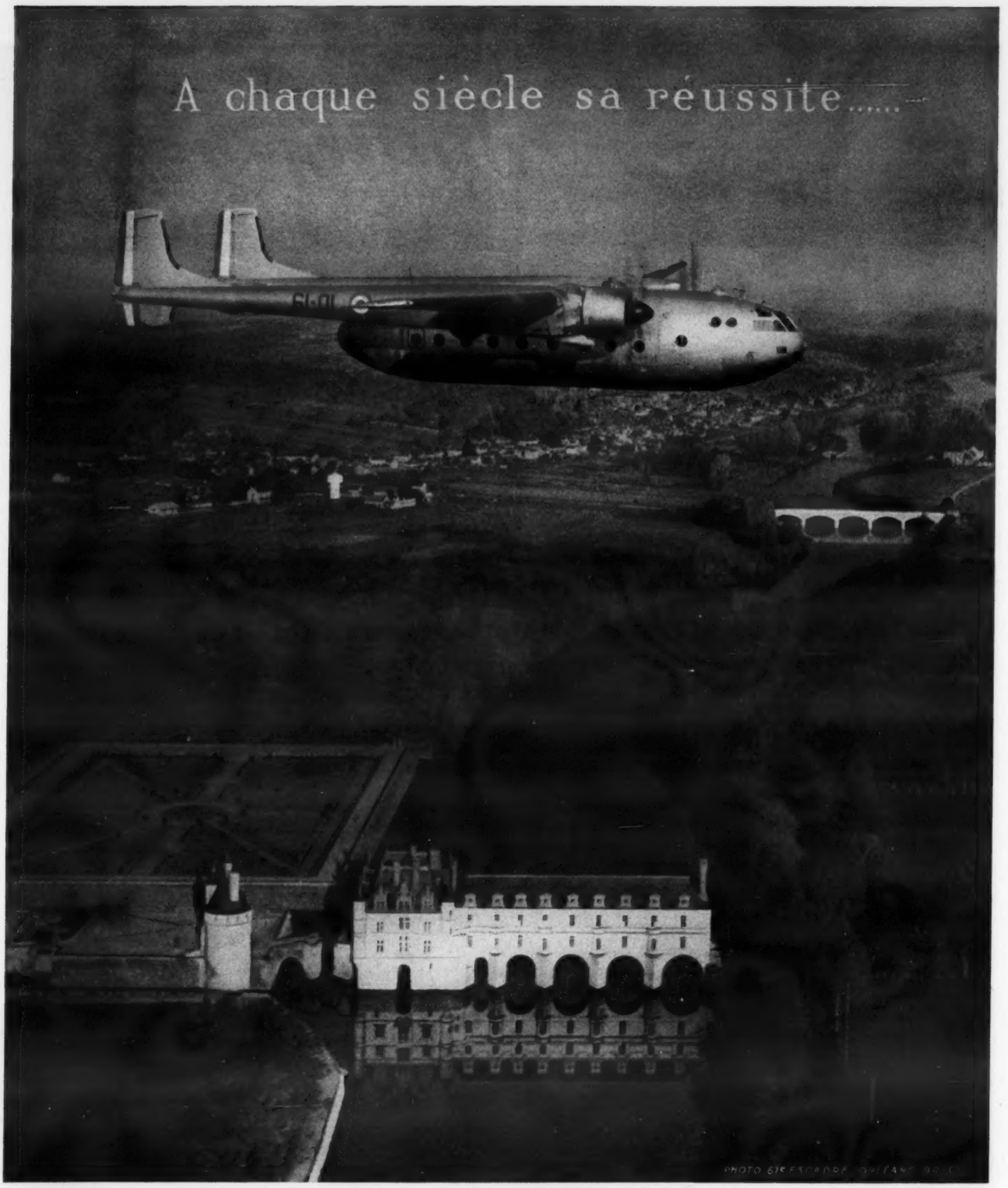

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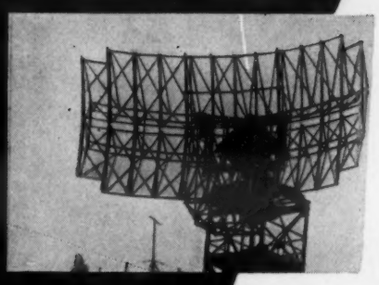

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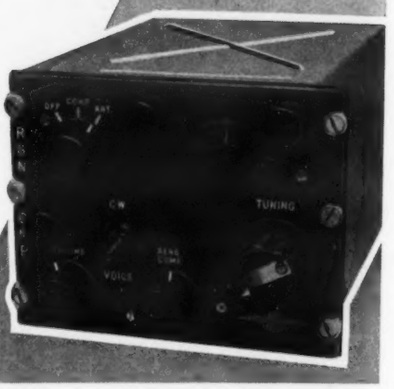
Its construction is such that its components can be installed, without special tools,

— in a shelter (staff command post)
— in a control tower

The transmitter and receiver can be mounted in an aircraft without internal modifications.
The station can be supplied together with a medium wave connection box to enable the transmitter to be used as mobile radio marker with an antenna power of 100 Watts.



MAIN CHARACTERISTICS

Transmitter
Frequency band: 2.5 to 20 Mc/s
Transmits on A_1-A_2 continuous waves
A_3 modulated waves
Pilot auto-oscillator with quartz frequency meter
Pilot oscillator: with 7 quartz
Antenna power 130 to 200 Watts

Receiver
Frequency band: 150 kc/s to 21 Mc/s
Operates on A_1-A_2-A_3
Quartz reference frequency meter
Selectivity: wide band
medium band
narrow band
Power supply: 127 or 220 volts from generator or network.

The TRANSISTORIZED INTERPHONE
Type IT-1

enables two persons to converse over short distances despite a high ambient noise level.

CHARACTERISTICS

Input impedance: 75 Ω (at input)
Output impedance: 600 Ω (at output)
Sensitivity: < 1,5 mV for 200 mW.
Output power: 200 mW.
Power supply: 3 standard 1.5 V torch batteries in series
Consumption without modulation: 10 mA approx.
Consumption for 200 mW: 70 mA approx.
Weight: 0.85 kg.
Dimensions: height 47 mm, width 124 mm, depth 124 mm.

The RANGE and HOMING RECEIVER
Type RCB-1

gives reception

— of radio ranges
— of directional radio beacons
— of omni-directional beacons.

It also provides homing navigation through use of the left-right indicator.

CHARACTERISTICS

Power supply: 27.5 volts
Total consumption: 2 A
Frequencies: single band of 200 to 800 kc/s.
Sensitivity: 50 μ V/m for homing.
Selectivity: 2 kc/s at 6 dB.
8 kc/s at 60 dB.
Output power: 300 mW on 300 Ω
Weight: 5.5 kg (power supply, frame, and indicator included).

AE

AIR-EQUIPEMENT

18, RUE BASLY - ASNIÈRES - (Seine)

FIAT
AVIAZIONE

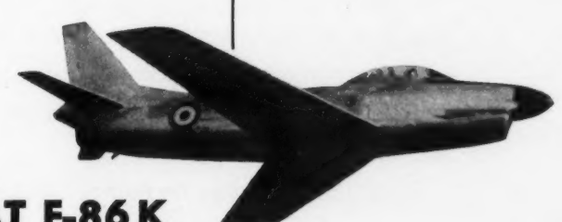
FIAT JET AIRCRAFT

FIAT G 91

Bristol Orpheus engine
light tactical support
fighter for N.A.T.O.

FIAT G 82

R.R. Nene RN 6/21 engine
advanced and operational
trainer



FIAT F-86 K

(North American Aviation
licence)

General Electric J-47-GE-
17/B engine
all-weather fighter

FIAT

DIVISIONE
AVIAZIONE
Corso G. Agnelli, 200
TURIN (Italy)

The fuel goes 'round and around

Between the arms of this ENGLISH ELECTRIC test rig at Warton there is room to put the fuel system of a modern jet aircraft—full size, and complete with all tanks, pipes, pumps, vents and cocks.

From the tanks can be pumped fuel at any desired rate up to that representing the full throttle take-off condition. Into it can be pumped simultaneously enough fuel to keep the level at any required point—thus maintaining steady conditions of test.

And while all this pumping and counter-pumping is going on, the entire outfit can be rotated bodily through any required angle, at any required rate of rotation (within limits), thus simulating as nearly as may be the effect on the fuel system of high-speed manoeuvres in flight.

If the test rig proves that the calculations of the ENGLISH ELECTRIC test team were correct—well and good. If not—how much better that defects should be shown up on the ground than in the air! In this open-minded atmosphere the long, costly and elaborate testing on the ground does a lot to shorten the much longer, and certainly more dangerous, process of trial and error in the air.

'ENGLISH ELECTRIC' aircraft

QUEENS HOUSE · KINGSWAY · LONDON · WC2

Partners in Progress with Marconi and Napier in THE ENGLISH ELECTRIC GROUP

Design starts from an attitude of mind

INTERAVIA

Deadline Notes

No. 10, 1956

GERMAN INDUSTRIES FAIR IN BERLIN: The French aircraft industry was represented at this Fair by no less than 17 companies. When opening the French pavillion, Georges Glasser, President of the French Aircraft Manufacturers Association, called for close cooperation between the French and German aircraft industries. In view of the impending switch-over from manned aircraft to guided weapons, cooperation between the two countries was more important than ever. The financial burden would become too heavy to be shouldered separately by the aircraft industries of each country.

THE U.S. CONGRESS is to make a meticulous review of the ownership of several important defence plants to prevent "leakage" of classified information to foreign countries. The Senate Internal Security Committee is reportedly particularly interested in holdings by Swiss and Canadian banks.

THE THIRD I.C.A.O. AIR NAVIGATION CONFERENCE in Montreal discussed problems involving the airworthiness and operation of aircraft, the replacement of present airworthiness standards by a new code, clarification of operational control procedures and definition of responsibility (of operators, aircraft captains, ground personnel), revision of the requirements for pilots of passenger-carrying aircraft, the value of rearward-facing seats and anti-collision measures, including the introduction of "anti-collision" lights.

THE BRITISH ARMY has taken delivery of the first Corporal surface-to-surface guided missiles from the United States. It is expected that the British Army of the Rhine will be the first Army group to be equipped with the Corporal.

GREECE IS THE THIRD N.A.T.O. COUNTRY, after France and Italy, to use Republic RF-84F fighter-reconnaissance aircraft.

THE GOVERNMENT OF INDIA has decided to order 25 Folland Gnat fighters for the Indian Air Force. At the same time it is planned to manufacture additional Gnats under licence at the Hindustan Aircraft Co.

CANADA'S FIRST NATIONAL CONFERENCE on engineering, scientific and technical manpower was held in St. Andrews, New Brunswick, from September 10th to 14th, under the auspices of A.V. Roe Canada Limited. To overcome a coming shortage of technically trained personnel, industry representatives pledged more than $100,000 to finance the work of the Industrial Foundation on Education and an exploratory committee to look into the feasibility of establishing a national advisory committee on the advancement of education.

LOCKHEED'S ELECTRA PRODUCTION PROGRAMME is continuing on schedule, the company announces in reply to rumours circulating in New York and Washington that production plans might be abandoned. Some 128 orders have already been placed, and talks have been held with several other airlines which will in all probability lead to new orders. Airlines which have ordered Electras include American, Eastern, Braniff, National, Delta, K.L.M. and Western. American is due to receive 35 aircraft in August 1958. Lockheed officials said some changes are being made in the interior of the aircraft for American (six-passenger compartment arrangement instead of rows of five seats) but these would not delay delivery.

QANTAS EMPIRE AIRWAYS' decision to buy seven Boeing 707/138s at a cost of £A 18,800,000 was influenced by two major factors: it gave the Australian international airline jet equipment six months earlier than if either the bigger 707 or the DC-8 had been ordered and avoided the necessity of buying an interim type. Q.E.A. will thus be the first airline to introduce jet equipment over the South Pacific.

THE MEMBER AIRLINES OF AIR RESEARCH BUREAU (Aer Lingus, Air France, Alitalia, British European Airways, Deutsche Lufthansa, K.L.M., Sabena, S.A.S., Swissair) recorded in 1955 a 23% increase in traffic volume over the previous year. Today roughly 90% of total European scheduled traffic is carried by A.R.B. members.

HELICOPTER SERVICES IN HOLLAND would not pay at present, is the conclusion of the special committee set up by the Minister of Transport and Waterways to investigate the subject. This situation, the Committee believes, is unlikely to change before 1960 when larger helicopters are expected to be available. On the other hand, helicopters will continue to play an important role in special operations such as crop spraying, rescue work, etc.

* From INTERAVIA's world-wide news service, including INTERAVIA AIR LETTER, the daily international aviation news digest. — No part may be reproduced without written permission.

UNDER SABENA'S 1956/57 WINTER TIMETABLE flying times on long-distance routes will be substantially cut when the Douglas DC-7Cs come into service in January: Brussels-New York from 16 hrs to 13 hrs 10 mins; Brussels-Leopoldville-Johannesburg from 20 hrs 20 mins to 19 hrs 15 mins. The longer range of the DC-7Cs will make it possible to eliminate some of the intermediate stops, such as Gander on the trans-Atlantic route and Kano on the Belgian Congo route.

K.L.M. AND THE EAST GERMAN LUFTHANSA have concluded an agency agreement under which the two companies will represent each other and act as one another's ticket agents. According to reports from Berlin, the East German company is negotiating similar agreements with several other West European operators.

THE U.S. CIVIL AERONAUTICS ADMINISTRATION has established a new ten-mile wide airway from Southern California through the Grand Canyon east of Colorado in a move to avoid accidents similar to the one in which 128 persons were killed at the end of June. The airway will require installation of ground-control stations, with navigation and radar communication equipment at a number of points in the thinly-populated areas in the Southwest. The new facilities are expected to be in operation by next spring.

THE SOVIET UNION should prove its peaceful intentions by lifting the Iron Curtain and permitting unchanneled tourist traffic, said outgoing President Juan T. Trippe at the opening session of I.A.T.A.'s 12th Annual General Meeting. An early application by Aeroflot for admission to I.A.T.A. would be "convincing evidence" of such a change of mind. Lord Douglas of Kirtleside, Chairman of British European Airways and new I.A.T.A. President, after talking with the Soviet Air Attaché in Britain, said that such things could not be rushed and added that he doubted whether Aeroflot would join I.A.T.A. much before two years. - At its closing session the Meeting elected Tomas Delgado y Perez de Alba, President of Spain's flag airline Iberia, as I.A.T.A. President for 1957-58. The 13th Annual General Meeting will therefore be held in Madrid, with Iberia and Aviacion y Comercio (Aviaco) acting as hosts.

THE I.C.A.O. JOINT SUPPORT CONFERENCE in Geneva ended on September 25th in an agreement by 14 countries operating air services across the North Atlantic to jointly finance the establishment and maintenance of navigation facilities in Iceland, Greenland and the Faroe Islands. The countries which signed the agreement are Belgium, Canada, Denmark, France, Germany, Iceland, Israel, Italy, Netherlands, Norway, Sweden, Switzerland, United Kingdom and United States. The signatories agreed to pay about $2,400,000 in 1957 and $2,300,000 in 1958 to the Icelandic Government and $1,100,000 in 1957 and $1,000,000 in 1958 to the Danish Government. Commenting on the agreement, an I.C.A.O. spokesman said it was estimated that the number of passengers on North Atlantic flights would reach a total of 1,700,000 by 1960, compared with about 700,000 in 1955. Even today, at any given moment, there were 120 to 150 commercial transport aircraft in flight over the North Atlantic. It was not rare, he added, for the Gander control station to report the presence of over 125 aircraft in the area during periods of four to six hours.

*

WORKSHOP BRIEFS . . .

The XB-68 bomber under development for the U.S. Air Force at Glenn L. Martin is said to have a design top speed of around Mach 2, an operating altitude of well over 50,000 ft. and a range of between 2,000 and 3,000 miles. * Three Boeing B-47 Stratojets are to make an attempt in November to fly non-stop (with several in-flight refuellings) from a U.S. Air Force Base in Omaha to Melbourne, Australia and Launceton, New Zealand. It is calculated that the 8,300-mile trip can be completed in about 17 hours. * Monthly output of Mystère II and Mystère IVA jet fighters at Dassault's Mérignac plant is 35 aircraft. * The Lycoming T-53 turbine engine for use in helicopters has completed its U.S.A.F. 50-hour tests; first production T-53s (for the Bell H-40 helicopter) should be ready for delivery in the second half of 1957. * A development programme for the Pratt & Whitney J-75 turbojet plans to increase thrust from the present 15,000 lbs. to more than 18,000 lbs. without afterburner. * The first prototype of the Convair B-58 Hustler four-jet supersonic bomber has been completed. * A turbojet of medium power (approx. 1,500 lbs. thrust) is to go into production at the Turbomotors Division of Curtiss-Wright Corporation. It is designed for use in trainers and target aircraft. * The first Canadair CL-28 sea reconnaissance aircraft is nearing completion and should be ready for squadron service next year. * The U.S. Navy has awarded contracts for the design of small gas turbines in the 250 h.p. class to the following firms: Continental $52,308; Lycoming $59,113; Studebaker-Packard $57,690 and Turbomotors Division, Curtiss-Wright Corp. $50,085. * The Bell X-14 experimental VTOL aircraft is being fitted with two Armstrong Siddeley Viper jets. The aircraft is reportedly complete except for installation of the engines.

* * *

Preparing for Elections not Only in Washington - But Also in Bonn

An outsider would scent a holiday air in Bonn right now—but only an outsider. Behind the scenes more feverish activity is going on than ever, and a multitude of preparations are being made. For, just as U.S. domestic and foreign policies of the summer of 1956 are determined by the forthcoming Presidential elections, the West German Federal Republic shows that also in this respect it has docilely and gladly adopted American customs: by not later than September 1957 a new Parliament and thus a new Government must be elected in Germany, and, if certain signs are to be believed, it is possible that this will mean a new Chancellor, a new party coalition and new policies.

*

One sign may be seen in the activity which quietly is being deployed by today's bosses of German civil aviation.

Ministerial Director Dr. Knipfer, chief of the Civil Aviation Department at the Federal Ministry of Transport, and thus real boss of Germany's air transport, recently visited Frankfurt, reportedly in order to familiarize himself with the local atmosphere, because he might shortly transfer his residence there, either of his own volition or by the force of circumstances. Knipfer will reach the age limit next year and therefore is due for retirement. But he feels quite energetic and has no intention simply to drop the reins. Again and again it has been rumoured that he is aiming at the chairmanship of Deutsche Lufthansa, today held by Dr. Kurt Weigelt who is in his seventies. Lufthansa Chairman Knipfer? Why not? It is he who created the Deutsche Lufthansa as the Government's chosen instrument which he plays to the tune of the Ministry Department he heads. Another rumour, quite unconfirmed but not by any means improbable, has it that Knipfer's change of domicile would entail the move of the whole of Lufthansa to Frankfurt.

When Knipfer was invited by Transport Minister Seebohm or, more accurately, by the latter's Assistant, Ministerial Counsellor Kreipe, to assume his post in Bonn, the choice of Cologne as Lufthansa headquarters seemed to be practically inevitable. It was an indirect salute to Cologne's former Lord Mayor, today's Federal Chancellor. The city was not far from Bonn, seat of the Federal Transport Ministry and thus Knipfer's Civil Aviation Department. It lies more or less half-way between the Federal Republic's main airport at Frankfurt and the somewhat arbitrarily chosen main engineering base at Hamburg. Now, however, since Adenauer's re-election apparently seems doubtful also in Transport Ministry circles, Cologne becomes much less interesting as the main seat of Lufthansa than the old city on the Main, for Frankfurt is the meeting point of all the air routes of the German Federal Republic. Thus a move of Lufthansa's management to Frankfurt looks possible.

In these circumstances the present system of decentralization could hardly be maintained, for Knipfer as Lufthansa's Chairman would wish to exercise direct control over all the company's activities. Geographically, the engineering services at Hamburg would be too far away and hardly rational. The administration of the Hanseatic City has no doubt "smelled a rat" and no longer seems inclined to make available vast funds for the necessary expansion of Lufthansa's technical facilities. Altogether, therefore, a fundamental reorganization of the German flag carrier's structure would appear to be in the offing.

There remains the question of what Federal Transport Minister Dr. Hans Christoph Seebohm has to say about all these projects. The experts don't agree in this respect. Some think that he will give his blessing—whether he likes it or not—to the ambitions of his collaborator Knipfer. Others assert that Seebohm has already chosen an industrialist whom he personally appreciates as Chairman of Lufthansa and prior to the elections will do everything in his power to lift him into the saddle.

Ministerial Director Dr. Kurt Knipfer, head of the Aviation Section of the Transport Ministry, reaches retiring age next year and is said to be aiming at the Lufthansa Presidency.

Federal Transport Minister Hans-Christoph Seebohm, who is said to be interested in the Presidency of the Federal Railways, should he retire from his present post.

There is no question that Seebohm, too, is getting ready to retire from his post, not only for party-political reasons but also because of a considerable opposition which is discernible among the uncounted voices of public opinion. While Knipfer wants to be Lufthansa's next Chairman, his Minister is credited with the ambition of occupying the President's seat of the German Federal Railways. It so happens that the present holder of that seat, Professor Frohne, too, is about ready to be pensioned off, and the agile Seebohm feels at home in every branch of transportation—in fact, Frohne always describes him as the most versatile of self-taught experts and improvisers. As Federal Railways President he would be one of the best-paid functionaries of the West German Federal Republic. Thus it is by no means regarded as unlikely that prior to the elections the Chancellor will make this gift to Seebohm to speed a loyal lieutenant on his way.

To sum up: the experts are nearly unanimous in predicting a change of Government. A move of Lufthansa's headquarters is the subject of discussion. Closely connected with the change of Government, a reorganization of the Lufthansa Board—consisting mainly of Government representatives—would take place. The consequence might be a number of changes in Lufthansa's management which certainly would not fail to have an effect on the company's future policies.

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There is even more activity in the military sector.

Federal Defence Minister Theodor Blank may relinquish his post after the 1957 elections, according to responsible German newspapers (above, left).

Minister of Atomic Affairs Franz Josef Strauss, who is tipped in Parliamentary circles as candidate for the projected Secretariat of State for Air (above, right).

Lieutenant General Joseph Kammhuber, head of the former German night fighter organization, took over the post of *Air Force Section* head and *Air Force Inspector* at the Defence Ministry in July 1956.

Although a few manufacturing companies of medium or minor importance have been awarded the first, small funds from the trinity formed by Bonn's Defence, Economics and Finance Ministries and thus been given the green light for a modest industrial activity in favour of the future German air force, the importance of these awards should not be overestimated. Of a German aircraft industry of respectable size there is as yet no sign. For two years the various production schedules have been dissected, announced and denied time and again, and now there is no *élan* left in them. Of what importance is the Government's gift of 35 million marks for the launching of an industry whose equivalent in the U.S.A. and the Soviet Union is backed by dozens of billions of dollars in investments, in Britain, France and Italy by several billion dollars? At the rebirth of the German aircraft industry a brake parachute has been placed in its cradle, and the optimism of certain industrialists—who all the same have reassembled a staff of designers and engineers—is nothing short of admirable.

In many ways the whole aspect of West Germany's rearmament is paradoxical. Just before the Chambers went on their summer vacation a Compulsory Military Service Bill was driven through Parliament. The Opposition parties—who tomorrow may perhaps be extremely powerful—forcefully manifested their unwavering hostility to the Act. The new law not even establishes the duration of compulsory military service, but all the same conscripts are now being called to the colours. And the build-up of the new German armed forces seems to be based on a concept which certain military experts and orthodox planners had guarded for years as top secret in their desk drawers, although events have long proved it to be outmoded.

Many things have changed since 1949, when Chancellor Adenauer offered a German armed contingent to the then Occupation Powers. Has not a fundamental change taken place in the bases of a policy which seemed perfectly suitable at the time? Although the constellation of the Great Powers exists today as it was seven years ago... the rafters of the Western bloc are crackling audibly.

The world looks different from what it was seven years ago, even when viewed from the German Federal Republic. The technical revolutions of recent times are emphatically claiming a part in the shaping of policies. An upheaval is in progress. Taking the threat to peace or security as a starting point, science is today dictating the tempo in which the social and economic structure of the nations and their interrelationships must be modified. Has not the scientist, the engineer, almost reached the status of a moulder of policies—and not of military policies alone? Is it not conceivable that one day the statesmen will arise from among engineers and physicists? The idea that such a change in personal qualifications might form a guarantee of enduring peace is not at all outrageous—it is almost captivating. At any rate, the majority of today's politicians seem to have only a vague notion of the possibilities and dangers which slumber in the latest achievements of scientific research.

*

Thoughts of this kind may be behind the plans for a radical change in military concepts which are being discussed in Washington and London. Whether Bonn will come to similar conclusions cannot be ascertained at this time. And if such ideas do finally assert themselves in Western Germany, they will do so slowly.

Defence Minister Blank, who was called to his post by Chancellor Adenauer, has been given the protection of a "closed season", according to a major German daily newspaper. Such protection night prove to be harmful if a change of military policies came about. A recent announcement by the Ministry of Defence reveals that the Ministry's latest preoccupation is the design of a new "walking-out tunic" for the members of the armed forces. This kind of reform may hardly prove sufficient.

*

Unaffected by the birth pangs of the new Federal armed forces, untouched by outside influences Lieutenant-General Joseph Kammhuber early in July assumed the post of Chief of the Air Force Department at the Ministry of Defence and simultaneously that of Inspector-General of the Air Force. Kammhuber, creator of the World War II German night fighter forces and thus a technically experienced officer, is described as unorthodox, sober, free of the egotistical ambitions which are rampant in Bonn, and is said to hold some highly personal views on the way the new German forces should be set up. These views are said to differ considerably from those current in Bonn and to take into account the factors which have emerged from modern scientific knowledge. It is no secret that his *primary consideration* in building up his Air Force will be to create an effective air defence system. But will he be able to assert himself in the face of stiff opposition, particularly from the Army General Staff which has not yet been able to shed its classical-conventional doctrines? Will he be able to overcome the resistance he will encounter in Government quarters?

At the moment he is necessarily performing secondary tasks in an attempt to establish a solid basis for the new Service. Many things still are conspicuous by their absence, from the most elementary administrative regulations concerning pay, quarters and equipment to the fundamental rules governing recruiting of air crew and engineering personnel. The training of these men must be his primary concern, because they will form the foundation on which he can build.

*

It is unlikely that Kammhuber has had any say in the matter in the procurement of the initial supplies of aircraft and weapons, for these plans were worked out long before he assumed his functions. Political and personal reasons may have played a role in the selection of this equipment, for several types of weapon now on order hardly jibe with the "New Look" that is gradually becoming a topic of discussion also in Bonn. However, all this material must be regarded as the initial expendable equipment necessary to build up the new German Air Force, and while the sums spent on it may distress the Finance Minister, they are of no importance whatever when regarded in the light of ultimate planning and of the current German industrial and economic miracle.

In theory the new German Air Force and its chief are faced by an exceptionally happy situation, namely—nothing. It is free of obsolete ballast, it can start from scratch and take into account all the new knowledge which today is still puzzling the general staffs of all major nations.

EEH

"Little Wars" Need Big Battalions

BY INTERAVIA STUDY GROUP

At Suez the smiles of Geneva have turned into grimaces. Relations between East and West have returned to their old sinusoidal course, and once more are approaching the trough of the wave.

Early this year the British White Paper on Defence placed the atomic weapon at the head of today's strategic factors: "In the deterrent must be included an effective early warning system and the ability of the forces of N.A.T.O. to hold the line by land, sea and air until the nuclear counter-offensive has broken the back of the enemy assault." Thus what was envisaged was an aero-atomic defence force backed by land and naval forces, whereas only a few years ago the nuclear arm was regarded merely as a complement to these same land and naval forces.

On June 19th, the day after the last British troops evacuated the Suez Canal Zone, General Nathan F. Twining appeared as witness before the U.S. Senate subcommittee on airpower. In his testimony the U.S. Air Force Chief of Staff said in substance: we cannot afford to keep on conventional units among our armed services alongside forces designed for atomic warfare... we must realize that we cannot have everything. I believe the British have already realized this... and perhaps the Russians... And the press announced that the U.S. Administration was planning to reduce present military strength by several hundred thousand men.

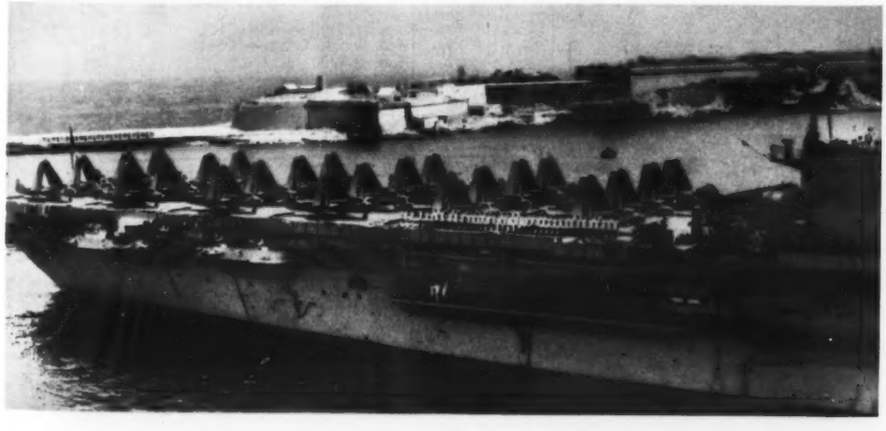
Less than a month later, when asked by the "New York Times" military correspondent what was the significance of the partial demobilization of Russia's forces, Soviet Marshal K. Zhukov replied that "future wars would require large armies and tremendous quantities of ordinary arms, despite the development of air power and nuclear weapons... The new combination of air power and nuclear weapons by itself cannot decide the outcome of an armed struggle."

Meanwhile, West Germany is working on its rearmament and planning a conventional Army and Navy, and an Air Force whose composition remains roughly similar to that projected when the European Defence Community was planned; that is, three or four years ago, when the idea of the general use of atomic weapons had not yet been accepted.

Discussing the Air Force's participation in the North African operations at a press conference on April 13th, 1956, the French Air Staff stated that by October nearly half the Air Force strength—64,000 men—would be stationed in North Africa. A force of 1,400 aircraft would then be available there, largely composed of piston-engine combat aircraft, transports and helicopters, or in other words equipment particularly well suited to the task of maintaining order and fighting the guerillas.

France has to keep 350,000 conventionally-armed troops under arms for the pacification of Algeria.

"Little wars" also need modern equipment: the aircraft carrier H.M.S. *Bulwark* carrying Hawker *Sea Hawk* jet fighters lying at Malta during the Suez crisis.



Five military concepts

This brief review of the major Powers' military policies underlines the far-reaching divergences in doctrine which the events of recent years have imposed on these countries. An old residue of isolationism provides the background to General Twining's views. Economic pressure leads Britain to concentrate primarily on a monovalent system, leaving the needs of the cold war to be met as a sideline within the limits of the funds available. ("Our forces must play their part in the cold war... They must be capable of dealing with outbreaks of limited war, should they occur," says the White Paper.) The military authorities in Bonn are working to old programmes and are to a large degree dependent on supplies of foreign equipment. France has been fighting overseas for more than ten years and has had to make a double effort to hold its two fronts, of defence in Europe and, on the one hand, yesterday's war in Asia, on the other, today's police action in North Africa. Situated between present realities in

North Africa and a possible future atomic war with Europe at stake, she naturally tends to give greater attention to the more immediate threat and has thus been obliged to build up the specialized air arm needed for this purpose.

There remains the Soviet Union. Marshal Zhukov's views are not merely those of an Army man who is also Minister of Defence. They correspond to the Marxist-Lenin doctrine, while at the same time justifying one of the essential instruments of Soviet diplomacy, the existence of mass armies capable of imposing respect and supporting Russian diplomacy in its efforts to nibble into the Western world.

Such was the position when the Suez Canal offensive was launched.

No neutralization of nuclear weapons

The 1955 Geneva Conference had dimmed the spectre of the cold war and encouraged the advocates of security through atomic weapons and a reduced, essentially aero-nuclear force. Suez may lead to a revision of this new concept.

In the West, the two great Anglo-Saxon powers are right in seeking to base their own security on a system of weapons capable of dissuading any adversary from resorting to aggression. It has been said that nuclear parity

Russian airborne troops.

West Germany is to set up "classical" land and naval forces, at least according to present plans. Members of an infantry training company with anti-tank weapons.

Three Different Types of Air Armament are Needed

The following table shows the aircraft suitable for the three possible forms of war (atomic warfare, local conflicts, colonial unrest). Though not claiming to be complete, the list reveals that a one-sided aero-atomic force would ignore realities.

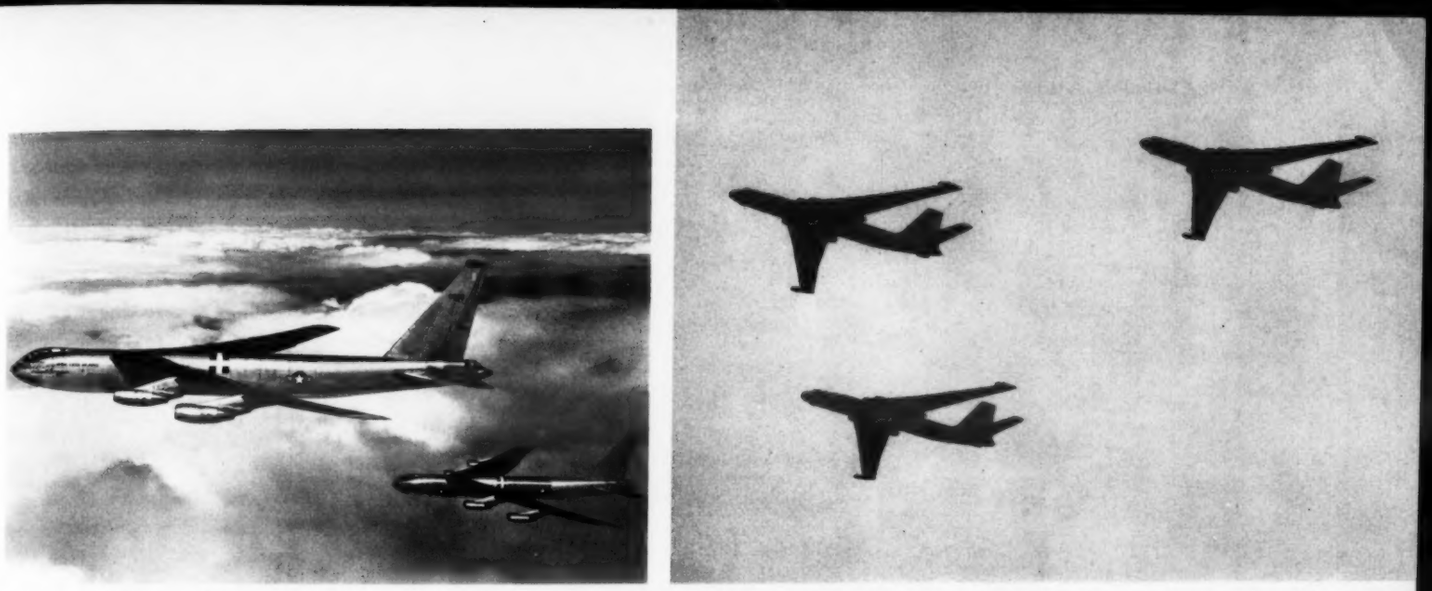
Special equipment for the three forms of warfare

(excluding naval air forces)

Mission	Today's equipment	Future equipment
Atomic warfare A world-wide conflict would probably begin with a mass atomic air attack.	**Bombers** Boeing B-52, Convair B-36, Boeing B-47, Martin B-57, Douglas B-66, Avro *Vulcan*, Vickers *Valiant*, English Electric *Canberra*, SO. *Vautour* and various fighter-bombers.	**Bombers** Boeing B bomber (project 110), Convair B-58, Lockheed bomber (project 125) with atomic propulsion, Avro supersonic bomber, Handley Page *Victor*, Republic F-105, and other fighter-bombers.
	Fighters, tactical aircraft Convair F-102, McDonnell F-101, North American F-100, Northrop F-89, North American F-86, Republic F-84, Avro Aircraft CF-100, Hawker *Hunter*, Vickers-Supermarine *Swift*, Gloster *Meteor*, Gloster *Javelin*, de Havilland *Venom*, Dassault Mystère IV, SO. *Vautour*.	**Fighters, tactical aircraft** Development of the "Century Series" fighters, Lockheed F-104, Avro Aircraft CF-100, English Electric P. 1, Saunders-Roe SR. 53, SO. *Trident*, SE. *Durandal* and SE. *Baroudeur*, Dassault *Etendard* and *Mirage*, Nord 1500 *Griffon*, Breguet 1000 and 1100, Fiat G. 91 and various VTOL and STOL types.
	Guided missiles Douglas/Western Electric *Nike*, Douglas/Emerson *Honest John*, Martin *Matador*, Firestone *Corporal*.	**Guided missiles** I.R.B.M. and I.C.B.M., anti-I.C.B.M.
Local conflicts In conflicts with limited objectives both sides would probably restrict themselves in general to non-atomic weapons and use tactical A-weapons only against military targets.	**Bombers** Boeing B-47, Martin B-57, Douglas B-66, English Electric *Canberra* and various fighter-bombers.	**Bombers** Appropriate developments.
	Fighters, tactical aircraft North American F-100, North American F-86, Republic F-84, Hawker *Hunter*, Vickers-Supermarine *Swift*, Gloster *Meteor*, de Havilland *Venom*, Dassault *Mystère IV*.	**Fighters, tactical aircraft** Developments and Fiat G. 91, Dassault *Etendard* and *Mirage*, SE. *Baroudeur*, Nord 1500 *Griffon*, Breguet 1000 and 1100, VTOL and STOL types.
	Guided missiles Douglas/Emerson *Honest John*, Martin *Matador*, Firestone *Corporal*.	**Guided missiles** Appropriate developments.
Colonial unrest Political undermining with sporadic use of force (guerilla actions etc.).	Armed light aircraft and trainers (e. g., North American T-6, T-28, Morane-Saulnier MS. 733 etc.), special aircraft (e. g., Potez 75, SIPA 1100, SE. 116 *Fonceur* etc.) and small transports (e. g., de Havilland-Canada *Beaver* and *Otter*, de Havilland *Dove* and *Heron*, Hunting Percival *Pembroke*, Scottish Aviation *Pioneer* and *Twin Pioneer*, Max Holste MH. 1521 *Broussard*, Dassault MD. 315), as well as rotary-wing, VTOL and STOL aircraft.	

Common equipment for all three forms of warfare

Long-range transports	Douglas C-133 and C-132, Lockheed C-130, Douglas C-124, Bristol *Britannia*, *Comet 2*, Breguet Br. 765 and requisitioned civil fleets.
Assault transports	Fairchild C-123 and C-119, Blackburn *Beverley*, Bristol *Freighter*, Nord 2501 *Noratlas* and various STOL types plus medium and heavy helicopters.



In future the bigger countries will have to carry the burden of two types of armament, strong battalions against "nibbling" and atomic air forces for a possible world conflagration. Russian Ilyushin *Bison* four-jet strategic bombers (right) and American Boeing B-52 eight-jet intercontinental bombers (left).

would invalidate this view and that, once they reached a high enough level, the nuclear stockpiles on both sides would cancel each other out, thus again giving mass armies the upper hand over smaller contingents. The truth has proved to be less simple.

Like all military resources, the nuclear system is revealed as a kind of chain with many links. In broad outline, it is a function of the projectiles available (number and power), the means of delivery (aircraft, missiles, guns etc.), the efficiency of the enemy's defences, the protection of the offensive or counter-offensive resources and above all, in view of the risks involved in its utilization, the will to resort to the use of nuclear force. All these elements, all these links in the atomic chain would have to be developed to the same degree on both sides before there could be mutual neutralization of nuclear weapons systems. Every chief of staff must be prepared for a temporary inferiority of one of these elements and hence reject the theory that nuclear weapons can be neutralized.

Limited war and atom bombs

British and American spokesman have frequently stated that they would not hesitate to use small atomic weapons against purely military targets in the event of a trial of strength involving a limited stake. The White Paper says: "In such limited wars the possible use of nuclear weapons cannot be excluded." Addressing a group of air experts on February 4th last, U.S. Air Force Secretary Donald A. Quarles stated: "I do not believe that we will ever again have to employ our air power and weapons as we did in Korea. If we are again forced into armed combat, we will use the weapons most appropriate to targets and missions... Today a single bomber, or missile, or even a fighter-bomber can deliver on target as much explosive force as all the World War II bombers combined."

It is obvious that the determination to use weapons with a high destructive power in a limited conflict may be a decisive factor in preventing war. But it is also clear that the situations in which this determination to use nuclear weapons could be translated into action would depend on the following factors:

1. The importance of the objective which the aggressor sought to achieve, either directly or indirectly.

2. The nature of his aggression, the military aspect of the attack and the vulnerability of his forces to nuclear reprisals.

3. The risk run by the defender that the atomic counter-offensive might develop into a chain reaction and ultimately expand beyond the limits it was desired to set to the conflict.

4. Political climate, international situation, world opinion—in short the "environment" of the conflict.

It is not necessary to be a politician or a strategist to realize that in favourable circumstances any country nurturing aggressive designs can satisfy them provided it can ensure the correct scope of its action. It is merely a question of keeping an attack too small to justify the use of highly destructive weapons and

Extremely "conventionally" equipped patrol of Britain's 40th Field Artillery Regiment in the hills of Cyprus.

French jeeps and armoured cars on patrol in an Algerian oasis.

French cross-country armoured cars in a road check in Algeria.

A *Thunderbolt* being loaded with rockets for a ground attack mission.

Germany is largely dependent on supplies of foreign military equipment. N.C.O.'s from a training company getting acquainted with an American *Patton* tank.

World War II *Thunderbolts* serve their purpose fully in Algeria.

taking advantage of the restrictions which the Western democracies have imposed on themselves. Thus the two Western Powers that possess nuclear weapons could scarcely affirm their determination to use them unless the gravity and the environment of the conflict justified such reprisals. Though their use would be certain if their owner's life were threatened, it would be less likely if only secondary interests were at stake or if the interests involved were those of allied non-atomic countries.

In this year of grace 1956 an examination of the map of the world shows that there are still vast territories and great riches that can be conquered by "nibbling", that is by aiming each time only at targets sufficiently limited to deprive the West's "decisive"—and also economical—weapon of value and sufficiently substantial to ensure that ultimately the whole Western edifice crumbles away.

In this case both doctrine and organization of the armed forces change. General Dale O. Smith has written in substance that in global war the old principle of winning aerial supremacy becomes devoid of meaning, since the amount of destruction that can be inflicted in a few days, or even a few hours, does not permit a return to the World War II strategy aimed at progressive attrition of the enemy's air potential preparatory to invasion and territorial exploitation of the aerial advantage. This notion of aerial supremacy comes into its own again, in certain circumstances, in localized conflicts. It presupposes extensive aerial resources and thus is not compatible with the organization of air forces designed to wield the "big stick", which can be small in numbers.

This reveals clearly the illusory nature of armed services organized solely around nuclear weapons. Admittedly, the latter system has its advantages. It takes full advantage of present technical advances, enables numerical strength to be substantially cut and relegates to the past the need for building up large air and naval fleets. But it leaves a vast field of action open to the adversary. The problems involved in the new situation that has been created by the development of atomic weapons are multiple. To meet the nuclear threat, it is necessary to possess the means of retaliating atomically. To cope with the hundred and one other possible forms of intervention, it is still essential to line up big battalions and numerically powerful air and naval squadrons. If there is a permanent trial of strength, a vast combination of nuclear and non-nuclear weapons systems appears necessary, since security against massive aggression on the one hand and against "nibbling" on the other can only be provided by two different defence systems.

The Helicopter is the Maid of all Work

Atomic Bomb to Molotov Cocktail

France's SO. 1221 *Djinn* jet helicopter proved its suitability as a firing platform. Wire-guided SS-10 surface-to-surface missiles were mounted on either side of the fuselage.

The missiles are launched a few feet above the ground . . .

. . . and race towards their target . . .

The missiles approach the target . . . whereupon the helicopter makes off to escape the enemy's fire.

Some time ago a *Djinn* helicopter powered by a Turbomeca *Palouste* turbine was tested as a flying missile launcher. Surface-to-surface missiles of the SS. 10 type were mounted on either side of the cockpit, and the pilot was instructed to fly as close to the ground as possible, climbing only a little upon sighting a suitable ground target. The gunner then "ignited" his cable-guided missiles, which he was able to control as easily as if the launching site had been on the ground. Thus the SS. 10 surface-to-surface missile became an air-to-surface missile. Once its missiles had been released, the helicopter made off out of sight of the "enemy", taking advantage of terrain features. The object was to use the rotary-wing aircraft's vertical speed in order to emerge from over a hillcrest, a line of trees or a thicket, fire its missiles and then disappear again below the enemy's horizon.

Similarly, ingenious young engineers of Doman Helicopter Inc. equiped one of their helicopters with bazookas, after stripping it to reduce weight and free sufficient space to form a firing platform. Another version of the combat Doman is armed with six machine guns and six rockets.

Is the rotary-wing aircraft thus to add the ability to intervene directly in the fighting to its role of ambulance or transport vehicle? Is it to become not only a means of logistical support but also a platform for recoilless guns or even missiles?

At first glance the low speed of this class of aircraft would seem to exclude it from the firing zone. Six years ago, however, experiments in which a Bell helicopter was attacked by fighters—in this case three *Thunderbolts*—revealed the Bell's ability to evade the fighters' fire simply by descending vertically in autorotation. A few months later, in Korea, practical experience on the battlefield, under the most varied conditions, gave the American command full information on the extent to which the helicopter can operate in the combat zone.

In theory, the transport helicopter is no more vulnerable than a truck, said Colonel Matheny, of the Fort Sill school, recently. The expert in operational research agrees with the helicopter engineer that the rotor blade area forms only roughly 5% of the area swept by the rotor. And as the helicopter can rarely be aimed at vertically, the vulnerable area offered is only about half the machine's main section and 3 or 4% at best of the area swept by the blades. Only very quick-firing guns with a calibre of at least .5 inches would be dangerous.

Parallel with the experiments by the French firm of S.N.C.A.S.O. and Doman Helicopters in the United States, with the object of using the *Djinn* and the YH. 31 as firing platforms, Colonel Matheny envisages the formation of artillery units to be transported by helicopters. A regiment of 188 helicopters, operated by 1,186 officers, N.C.O.'s and men, could move eighteen 105-mm calibre guns to within good firing range of the enemy. All recent studies on the nature of a war in which nuclear weapons were used call for the dispersal of land forces over very wide areas. But though the space they would occupy would be vastly different from that in the old TNT days, the field artillery has not been able to increase its firing range accordingly. By combining guns with rotary-wing craft, Colonel Matheny seeks to inject new life into a branch of the armed services which has been severely affected by the rapid evolution in combat techniques. One can imagine the regiment of helicopter-borne guns taking up position within good firing range, launching its salvoes and moving away again immediately so as to escape the enemy's reply.

Colonel Matheny (U.S. Army) proposes that a whole artillery regiment should be equipped with Doman YH-31 helicopters.

The U.S. Army's Vertol H-21C helicopter dropping its auxiliary fuel tanks.

In addition to its mobility, such a regiment would be almost independent of the nature of the terrain. During exercise "Sagebrush" last year, U.S. Army Vertol H-21C helicopters succeeded in rescuing convoys of jeeps and freeing guns that had been immobilized by mud.

But the American expert on tactical problems and combined actions goes even further. He does not limit the helicopter to the role of transport. Colonel Matheny considers in fact that, if specially designed for the purpose, rotary-wing aircraft can serve as mountings or mobile launching ramps for nuclear-warhead missiles such as *Honest John*. Despite logistic difficulties, *Honest John* launching units could be transported by helicopter, with the combat group consisting of launching helicopters and supply helicopters. In addition to high fire power and respectable range, the new units would have the advantage of guaranteed mobility regardless of terrain. Travelling at low altitude, the missile-carrying helicopters could operate without risk of detection.

Helicopters for local conflicts and atomic war

● Utilizable in local conflicts
■ Combat missions in atomic war
▲ Auxiliary services for civil air defence in atomic war

●▲■ Ambulance duties
▲■ Supplies
■ Transport of larger units
●■ Transport of small commando units
● Indirect support of ground fighting
■ Artillery transport
■ Guided missile transport
●▲■ Salvage work in difficult country
▲■ Reconnaissance of landing grounds
▲■ Crane helicopters
●▲■ Communications services for the command
●▲■ Flying "command post"
■ Transport of divisional staffs
▲■ Regulation of ground traffic
●■ Reconnaissance
● Convoy protection
● Policing of rebel areas
▲■ Detection of radiation
▲■ Cable laying
● Warning and intimidation missions

The unconventional views of the Fort Sill school would meet one of the requirements of a vast conflict whose stake would be control of the whole world. At the other end of the scale of combat techniques and forms of warfare the helicopter is occupying an increasingly large place in the arsenal of the countries fighting on fronts of apparently secondary importance. The part played by rotorcraft in Korea, Indo-China and Malaya is well known, and enough has already been said on the number of lives they saved when used as ambulances, on their services as a means of communication, etc. According to the French press, the employment of helicopters in Algeria has made it possible to reconcile two forms of warfare hitherto diametrically opposed: guerilla warfare in which the qualities of the infantry are exploited to the limit, and the advantages of relatively complex technical development.

The main problem in Algeria is to be everywhere at once. Though the rebel forces form only a minute proportion of the population, they have the advantages of secrecy and mobility on their side. They strike only where they know they will encounter no immediate opposition. Apart from being unsuitable for this type of combat, no heavy forces could hope—unless they consisted of millions of men—to cover the whole country in the only way it is possible to deter the rebels from resorting to armed warfare. From the beginning Robert Lacoste, Resident-General in Algeria, has stated that his plan for pacification was based on dividing the country into military "boxes". The helicopter seems to have revealed itself as one of the essential instruments of this policy.

Thus, even in its present stage of development, the helicopter capable of carrying a little over two tons can become a military vehicle common to both extreme forms of warfare since it could play an important part in nuclear combat and has already been used with success in guerilla warfare.

Sikorsky S-55 helicopter with the French troops fighting in Algeria.

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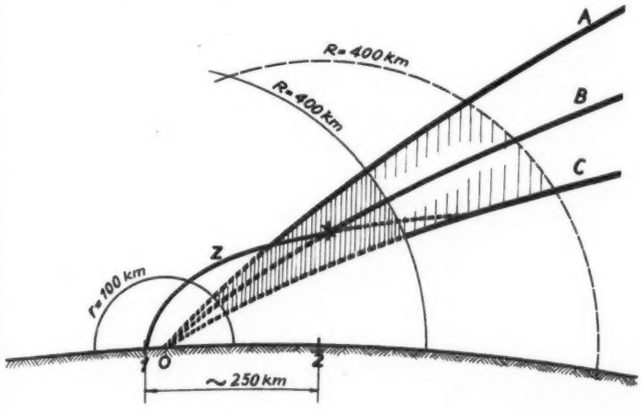
The Anti-Missile Missile May not be a Myth

More than half the V-2s launched against Southern England in World War II escaped radar detection. And only one third of the trajectories detected could be interpreted sufficiently accurately as to give the defence an indication of the area in which the missiles would fall. Admittedly, the launching sites were relatively close to the radar stations, and the V-2 was less than five minutes in the air. The experts examining the problem of intercepting the V-2 in 1944 came to the conclusion that the means available at that time could provide no solution. In view of the V-2s terminal velocity—5,900 ft./sec—and the proximity of the launching sites, anti-missile missiles would have been needed with an acceleration of several dozen *g* and capable of being fired before the V-2s arrived at the peak of their short trajectories. The scientific and technical resources then available were insufficient to develop a defensive system of this kind. A few months later, when the Allied armies were advancing towards the Rhine, groups of American scientists also tackled the problem previously examined by their British colleagues and came to the same conclusions. In other words, the offensive was clearly superior to the defence. After World War II the experts criticized the V-2, with its weight of 13 tons and its complex engine system to carry only 1 ton of TNT, as a relatively primitive weapon.

Today? With a nuclear warhead, it becomes a formidable weapon . . . although for the time being it is limited to medium distances.

The combination of an atomic warhead—and more particularly a thermo-nuclear warhead—and a ballistic missile complicates still further their interception in flight. The missile should not be destroyed at a distance smaller than the radius of destruction of the nuclear explosive it carries. General James H. Doolittle, scientific adviser to the U.S. Air Force, has hinted that several groups of experts are seeking a method of "neutralizing" the projectile during its descent. Of course he has not revealed whether other systems than interception by an anti-missile missile are, if not in view, at least rationally possible.

The space within which an enemy I.C.B.M. must be intercepted by the defence's anti-I.C.B.M. is delimited by two spherical surfaces roughly 60 miles and 250 miles in radius. The smaller sphere represents the destructive range of an H-bomb, the larger sphere the range of high-power surveillance radar stations. – A, B, C = three possible trajectories of an enemy I.C.B.M.; Z = path of ascent of the anti-I.C.B.M.; O = target of enemy I.C.B.M.; 1 = launching point of anti-I.C.B.M. and site of (central) radar near target; 2 = advanced site of (peripheral) radars which transmit their scope images to the defence rocket launching point (1).



British forerunner of the anti-I.C.B.M.: rocket-boosted ascent by an English Electric anti-aircraft missile.

Meanwhile, in the United States alone four groups known for the high quality of their scientific resources are working on the anti-missile missile. Some of them, such as Convair's *Atlas* I.C.B.M. group, are working on both the offensive weapon and defence against it. Their early conclusions are reportedly less negative than the experts who had to tackle the V-2 problem. The elements of the problem are different, and in theory at least the answer should be positive.

The I.C.B.M. would have to be intercepted inside the space defined by two hemispheres, one of them having as radius the range of radar detection of the offensive weapon, and the other corresponding to the volume to be protected as a function of the thermonuclear explosive's destructive effects. At the moment, if the detection system is located at the I.C.B.M.'s target and the launching site for the anti-missile missile (or anti-I.C.B.M.), the corresponding distances would be about 250 miles for detection and some 60 miles for the radius of the safety zone against the effects of thermonuclear explosions. A rough calculation shows that to ensure that the I.C.B.M. and anti-I.C.B.M. trajectories intersect outside the danger zone, the defence missile must have a very high initial acceleration in order to "catch" the I.C.B.M. in the remaining 190 miles. Otherwise the radar posts of the defence would have to be separate from the anti-I.C.B.M. missile sites and moved forward several hundred miles along the anticipated I.C.B.M. trajectory, which would necessitate equipment for the transmission of the radar images to the defensive missile sites as well as complicated computing equipment.

The problem of detection itself remains difficult. Admittedly radar echoes have been received from the moon (long distance, very big target) and radar equipment has been developed which detects the trajectories of artillery shells (short distance, small target). But a system of detecting the I.C.B.M. is very much more complicated since it must have a high selectivity (because of the I.C.B.M.'s small size), and a long range and at the same time be capable of scanning a vast portion of space. These requirements are obviously contradictory, and a great deal of effort will have to be made in order to arrive at an acceptable compromise. However, with the trumps already in the hand of the electronics engineers, the solution is not beyond reach if the defence can be content with a very short time lag between detection of a sufficient portion of the trajectory and the launching of the defence missile.

New difficulties	New possibilities
1. The I.C.B.M. has a terminal velocity about four times higher than the V-2.	1. Because of its high terminal velocity the I.C.B.M. generates extremely high friction heat on re-entering the atmosphere. This heat produces an ionized zone which renders radar detection easier.
2. Much greater area of destruction if this "ultimate weapon" has a thermonuclear warhead. The I.C.B.M. must therefore be intercepted and neutralized at a sufficient distance to prevent the effects of the nuclear explosive from being felt on the ground.	2. Longer trajectory time, of the order of 30 mins for a missile travelling 5,000 miles. But this defensive advantage is reduced by the fact that the greater part of the trajectory lies in space and that the above-mentioned ionization effect would not appear until the missile is below about 60 miles altitude. (Note that meteorite trails occurring between 50 and 60 miles altitude are detected by radar).
3. Possible variations in final trajectory, due either to the equipment carried by the I.C.B.M. or to a special adjustment before launching.	3. The friction heat produced during the last part of the trajectory could be used to guide the anti-missile missile.
4. Vital necessity of intercepting as many missiles as possible without learning period in view of the new probability of general surprise attacks.	4. The anti-missile missile can also be equipped with a nuclear warhead, thus greatly increasing its radius of destruction.
	5. Accelerations of nearly 20 g could be obtained in an anti-missile missile with power plant conceivable today.

British forerunner of the anti-I.C.B.M.: two Fairey *Fireflash* beam-guided supersonic air-to-air rockets under the wings of a Hawker *Hunter* interceptor. (Each rocket consists of a central body and two solid-propellant rocket motors attached by explosive bolts.)

American forerunner of the anti-I.C.B.M.: six Hughes/Philco *Falcon* beam-guided supersonic air-to-air rockets in the wing-tip containers of a Northrop F-89H all-weather fighter. (The rockets are moved out into the position shown just before firing.)

Incidentally, defence against *intermediate* range ballistic missiles may prove to be more difficult to organize than that on which the United States is working against the I.C.B.M. The warning available would obviously be shorter, and the effectiveness of the anti-missile missile may depend on a few extra seconds. It is doubtful whether even today an anti-V-2 missile could be developed, because of the V-2's very short "endurance". Thus, with the surface-to-surface missile, as with the aircraft, defence without territorial depth would seem to be virtually impossible.

Even if the technical problem of intercepting the I.C.B.M. in flight were solved and a high percentage of hits could be obtained, there would still remain the problem of obtaining a similar result under conditions of total surprise. A relatively small number of I.C.B.M.'s with thermonuclear warhead could destroy the towns of a powerful nation, along with its command and administrative apparatus. What is more, the vast medical and social problems which would have to be tackled immediately would have to be given priority over the organization of retaliatory measures—if they were not automatic—and of defence against further attacks. Since the number of missiles needed would be small, the initial attack could have the advantage of complete surprise. It follows, then, that the defence organization would have to be in permanent readiness, prepared for action within minutes, or even seconds. Because of the range of these missiles, the defence organization cannot afford to protect only certain selected "priority target areas" but must constantly scan a vast region in space—in the case of the U.S.A., for example, billions of cubic miles—searching for the proverbial needle in a haystack. It is therefore likely that the offensive will continue for some long time to come to dominate the defence.

Western Europe, the Arab States and Middle East Oil

From Mossadegh's nationalization of Iranian oil to Colonel Nasser's nationalization of the Suez Canal, the Middle East States have based all their dealings with the Europeans on the argument that without their oil Western Europe would be economically and militarily bankrupt.

Like so many other "arguments", this one also contains only part of the truth.

It is incontestible that the Middle East's oil plays a big part in covering Western power requirements—which rose by 230% between 1920 and 1955. The extent to which Europe depends on the Middle East oil-fields is spotlighted by the figures recently published by the Economic Council for Europe:

Sources of Western European oil imports 1937 and 1953

(in millions of barrels; 7 barrels = 1 metric ton)

Supply region	1937			1953		
	Crude	Refined	Total	Crude	Refined	Total
Middle East	31.5	22.4	53.9	505.4	9.8	515.2
North America	14.7	29.4	44.1	2.1	25.2	27.3
Latin America	31.5	22.4	53.9	29.6	57.4	87.0
Far East	2.8	35.0	37.8	0.7	3.5	4.2
Eastern Europe	2.8	25.2	28.0	1.4	4.2	5.6

In other words, the share of the Middle East States in supplying Western Europe rose from 7.7 to 73.5 million metric tons in fifteen years, while the combined share of North and South America increased only from 14 to 16.3 million metric tons.

Incidentally, American interests in the Middle East oil deposits are scarcely smaller than the Europeans'. Roughly 60% of all concessions for oil extraction are in American hands, and the value of the oil reserves held by the Americans in the Middle East is estimated at $270,000,000,000. Within the near future the West—both the United States and Europe—will become heavily dependent on these reserves, since although America's share in present annual world oil production is incomparably larger than that of the Middle East (United States approx. 60%, Venezuela 15%, Middle East 12%) the Middle East leads the world by far in known oil reserves (United States approx. 17%, Middle East 70%).

Just the same, it is doubtful whether the Arab States' calculations will work out, since Western Europe is practically their only customer. Compared with deliveries to Europe, the Middle East oil exports to the United States and Australia play a very subordinate role.

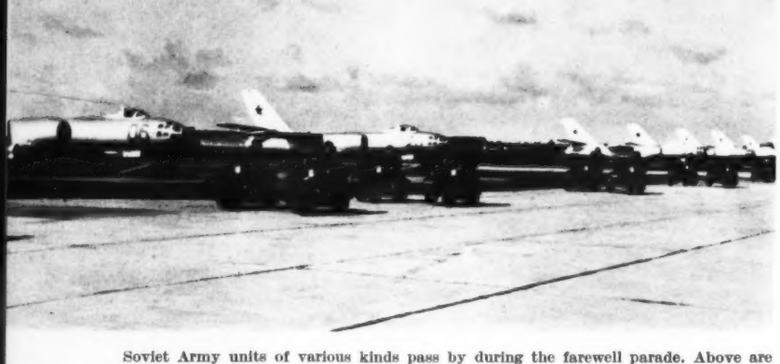
In addition, the cost of prospecting and producing are so high that, without Western investments, the Arab States would not be able to take one barrel of oil out of the ground. According to Dr. Joseph E. Pogue, well-known American economist and oil expert, capital investment in the world oil industry in 1955 reached more than £ 2,000,000,000. Between 1956 and 1960 he expects this sum to rise to some £ 3,500,000,000 and from 1961 onwards to £ 4,000,000,000 a year.

In other words, Arab threats to cut off oil supplies might be a two-edged sword. If Egypt closed the Suez Canal, and Syria at the same time blocked the pipelines which carry the oil from Iraq and Saudi Arabia, Western Europe would undoubtedly face a very serious situation. It would lose roughly one third of its present oil supplies and would have to get down to building a new fleet of super-tankers to carry oil from Iran and Kuwait round the Cape of Good Hope. The United States and Venezuela could also increase their oil production and thus make good some of Europe's losses. But here again additional tankers would be needed to carry the oil across the Atlantic.

However, by thus paralyzing European economy the Arab States would be cutting off their own noses. As their revenues from oil deliveries to Western Europe—at roughly $ 1,000,000,000 a year—form the lion's share of their budgets, they would have to accompany the Europeans to the bankruptcy court.

Ilyushin Il-28 light jet bomber. Seventy are said to have left Eastern Germany.

Final inspection of the aircraft. A pilot salutes his Commanding Officer.



Soviet Army units of various kinds pass by during the farewell parade. Above are motorcycle despatch riders.

"Geneva Spirit" in action . . . Frenchmen, Russians, Britons, even a German civilian. In the centre, General Newhearst, of the British Army.

Russian Squadrons Le

From a Special Correspondent in West Berlin

An urgent telegram from the East Berlin Press Relations Office told us just in time that the farewell parade at Oranienburg, near Berlin, by the departing Soviet Air Force units would start an hour earlier than originally scheduled, Sunday, August 26th, 1956. For the first time in years West German journalists were authorized to cross over into the German Democratic Republic—better known in the West as the Eastern Zone of Germany—without any formalities whatsoever.

The route? The area around Thälmann Square—formerly known as Wilhelm Square and centre of the old Government district—is deserted on this Sunday morning. Gaping holes and ruins everywhere, the former Palace of the President of the old German Republic, the Hotel Kaiserhof —disappeared. The remnants of the Reich Chancellery and of the *Führer's* "bunker" have been razed.

Had we remembered anything of urgency, some chore to be performed at home in West Berlin, we could have done . . . nothing about it. You cannot telephone from East to West Berlin, unless your call is diverted via Frankfurt-on-Main, long-distance. The cables have been cut. During the Foreign Ministers' Conference of January 1955 they were temporarily put together again, but only temporarily. On the other hand, if you want to telephone to Honolulu, there's nothing to stop you.

We have arrived at our meeting point where two motor coaches are awaiting the West German press representatives. The atmosphere is subdued, not all the journalists know each other, conversation is hesitant. The coaches describe a vast detour around the Western Sectors of Berlin as well as around Pankow, the East German Government district—which is popularly known as "Pieckhausen" after President Pieck and his residence Schloss Schönhausen. Finally we approach Oranienburg north of Berlin, where the ceremonies are to take place at the old factory airfield of the Heinkel aircraft concern's former headquarters plant.

*

There they are, parked in straight lines, the Ilyushin Il-28 twin-jet bombers bearing the Soviet star on their tails. "Under the programme of reducing Soviet military strength on German soil" they are to be flown home and "mothballed", while their crews are to return to their lathes and ploughs, as the official announcement says. Twenty-two aircraft are lined up along the runway, four dozen more further back. Will they let us inspect them? Soon we are close to them, amidst aircraft and crews.

Over there is Lieutenant-Colonel Ruban, of Kiev, who through an interpreter is glad to confirm that his relations with the German population had always been excellent, that he has been able to pursue his studies as a historian in Oranienburg, that he will return to teach at a university in his country, that he is leaving many good friends behind. Small girls offer bunches of flowers to the crews . . . Handshakes, embraces . . .

A pilot – note flying suit and cap – awaits the final order to get his machine ready for take-off.

s Leave Eastern Germany

At eleven sharp the actual parade begins. The squadron commanders report to the Commander-in-Chief, Marshal A. A. Grechko, that their units are ready for take-off. Guests at the parade are Americans, Britons, Frenchmen. A German speaker expresses his cordial thanks to the "departing soldiers of the Soviet armed forces who have helped so actively in building up socialism, in gathering in the harvest, in fighting fires and in organizing anti-whooping-cough flights . . ." The ceremonial address to his "dear Soviet and German friends" is delivered by the Deputy Prime Minister and Foreign Minister of the German Democratic Republic, Dr. Lothar Bolz: ". . . The Soviet example in lessening international tension by withdrawing from Germany and disbanding 64,000 troops—including three air divisions totalling 30,000 men—should be followed by other nations until one day all occupation forces have left the country . . . By putting a stop to the rearmament of Western Germany the Cold War could be ended, but Adenauer is pursuing the wrong course . . . The German Democratic Republic has now become a solid component of the peace front and will never countenance another aggression against the Soviet Union . . ."

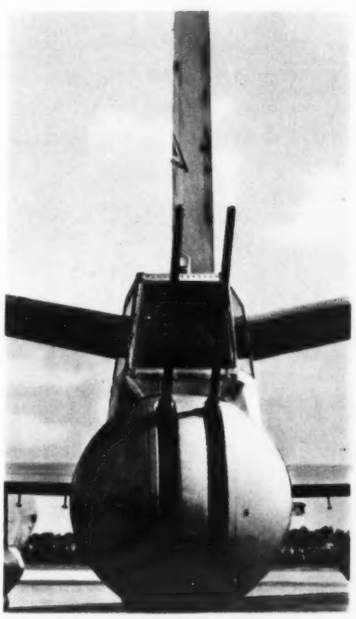
Electric Welder Kamscheit of the "Wilhelm Florin" steel and rolling mills (formerly AEG) at Henningsdorf, near Berlin, reads out a message to thank his "dear Soviet friends" for their now terminated presence in Germany and to bid them a cordial farewell on behalf of his colleagues. All addresses are translated, including that by Soviet Captain Agheyev, who declares in the name of his comrades how much they all love and have come to appreciate the hard-working German people and how hard it is for them to leave. The national anthems are struck up—for the German Democratic Republic the hymn "Risen from the Ruins", lyrics by Culture Minister Dr. Johannes R. Becher, music by Hanns Eisler, brother of the well-known ex-American communist.

Start of the military part. In blue flying suits the crews march past the grandstand, followed by armoured cars of the motorized infantry, anti-aircraft guns, light artillery, and at about the same time 32 Mig-17 fighters roar across the field. Bang . . . bang! The sonic booms of a MiG-19 which no one had noticed and now is climbing again. Will it also return home? Then come helicopter demonstrations, the jets of the Ilyushin Il-28's start up, dust swirls around and the screams of the engines drown out the noise of the wind which has been sweeping across the field at strength 12.

The spectacle is impressive, the military organization exemplary. Eighty thousand people are said to have come to the Oranienburg field from surrounding towns and villages, from Frankfurt-on-the-Oder to Potsdam, in order to applaud the departing air units of the Soviet Air Force.

Armoured cars bearing motorized infantry of one of the Soviet Army's crack regiments.

Army trucks with full gun crews draw 88-mm anti-tank guns.



Twin-gun tail turret (20-mm) of an Ilyushin Il-28.

One of the eight flights of MiG-17 jet fighters which flew over the base during the ceremony.

First three, then five Mil-1 helicopters demonstrate their prowess despite a strong wind. From the first group Soviet officers descended by rope ladder; the second group landed and disembarked a motorcycle and sidecar each.

Farewell! East German "Young Pioneers" hand flowers, a flag and blue scarves to the pilot of the departing group's lead aircraft.

Recent Trends in Aviation Electronics

BY DR.-ING. E. KRAMAR, STUTTGART

The author was born at Kladno, near Prague, on June 15th, 1902, studied electrical engineering at the German Institute of Technology in Prague and the Dresden Institute of Technology. He graduated as a Doctor of Engineering in 1927 and joined C. Lorenz A.G., then in Berlin, where he was initially engaged in making broadcast transmitters. By 1929 he had made his first contacts with aviation through the construction of a four-course MF radio beacon on the Schotter-Lorenz principle at Eberswalde and the investigation of night effects for Deutsche Lufthansa's airmail services to Königsberg. Four years later the first instrument landing beacon was erected, under Kramar's direction, at Berlin-Tempelhof. The basic principle used—differing morse signals on a VHF carrier on either side of the approach line and a continuous note in the centre—was soon accepted throughout Europe and was also successfully demonstrated in the United States (Indianapolis) in 1937. During the war the author developed the Sonne-Consol system of long distance navigation and "speaking rotary beacons" for short distance navigation by fighters. Appointed head of Lorenz's Navigation Laboratory in 1936, he is today Managing Director of the company and in charge of all radio development. *Editors*

"During the last weeks of the Korean War the U.S. Air Force made an interesting experiment. They put an infantry captain who had never flown before into the cockpit of a modern fighter on a Japanese airfield, closed the hood and launched the aircraft from an observation post resembling, with its radar scope, electronic apparatus, measuring instruments etc., a small automatic factory. The officer had been strictly ordered to do nothing but stare at the radar scope and twiddle his thumbs. He was forbidden to touch any of the instruments. The aircraft rose from the ground on 'command' from the control post, set course for the front near the 38th Parallel, engaged an enemy fighter, shot it down, made an elegant turn over the front and landed safe and sound again on the airfield in Japan. 'Very interesting', said the captain as he climbed out of the cockpit..."

This story—whose accuracy I cannot guarantee—recently appeared in a newspaper. It gives a good idea of the leading part which electronics plays in the air force today. But in commercial aviation too its importance is scarcely less great. A Lockheed *Super Constellation* carries about thirty times the weight of electrical and electronic equipment as the good old Junkers Ju 52. The electronic equipment in an all-weather fighter such as the North American F-86K *Sabre* costs as much as a complete Messerschmitt Me 109 fifteen years ago, i.e., roughly 250,000 Marks.

*

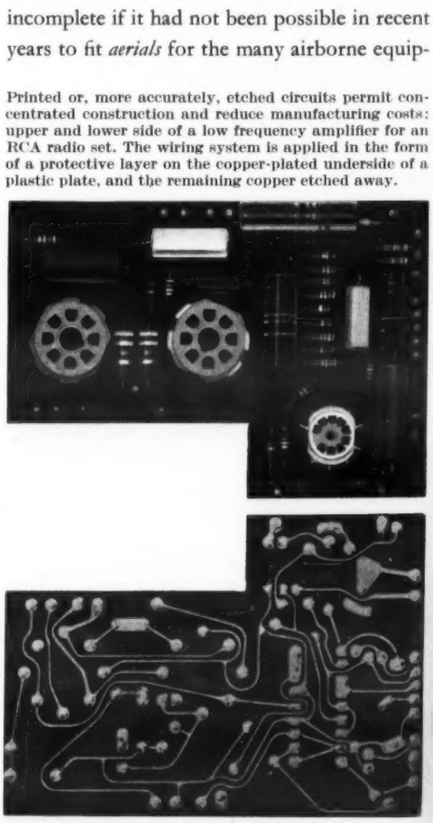
The aircraft manufacturers' pressing desire for a reduction in the weight and bulk of airborne electronic equipment is therefore understandable. Of late the radio and electronics industry has acquired a series of promising aids to meet this desire. The *electron tube* has shrunk to about a quarter of its original volume in the past 15 years; in many cases (in particular for intermediate and low frequencies) it can today be replaced by transistors. The latter "tube replacement" based on germanium rectifier techniques not only offers great advantages because of its small dimensions and the simplified wiring structure it permits, but also reduces power consumption since it has no heating.

Today valves are being increasingly replaced by transistors: comparison between a modern British electron tube of normal size (Osram), a miniature tube (Mullard) and an RCA transistor for the same purpose (power amplifier).

Printed circuits permit condensed construction of electrical components, which themselves are being miniaturized to an extent that would have been inconceivable even a short time ago. *Modular design,* i.e., building up whole sub-assemblies out of flat units inserted in the base plate like leaves in a book, is another step towards reduced bulk, simplified maintenance and easy replacement of faulty parts.

All these measures would, however, be incomplete if it had not been possible in recent years to fit *aerials* for the many airborne equip-

Printed or, more accurately, etched circuits permit concentrated construction and reduce manufacturing costs: upper and lower side of a low frequency amplifier for an RCA radio set. The wiring system is applied in the form of a protective layer on the copper-plated underside of a plastic plate, and the remaining copper etched away.



ments flush with the *aircraft skin*, thus avoiding the rapidly increasing drag of external aerials with increasing speed. A whole branch of science is carrying out measurements on aircraft models, in an effort to solve remaining problems, in particular the difficulties presented in communications by the directional characteristics of the high frequencies now used. The introduction of airborne radar to detect dangerous turbulence areas set the antenna planners new problems and demanded a high degree of understanding on the part of aircraft designers. The radar nose of today's giant civil transports shows how fruitful this collaboration has been.

Needless to say, steps have been taken to reduce the weight, bulk and cost of aircraft equipment by *collecting different functions* in the same frequency band in combined receivers: VOR/ILS equipment (for short-distance navigation and landing) in the VHF band (Standard of London, Collins, Bendix); radio compass and four-course radio beacon receivers in the MF band (Marconi, Lear) etc. This tendency has even been pushed as far as combining, in particular in sports aircraft, VHF communications with navigation (Narco, Lear).

Another trend is towards facilitating the pilot's task by giving him "flyable" readings on a small number of compact instruments, in some cases using automatic computers to combine aircraft position fixes with the values obtained by radio navigation, Both Collins and Sperry have developed such *integrated flight systems*. Decca makes the well-known *Flight Log* which keeps the pilot informed at all times of the route covered and his position at any given moment, and sooner or later will eliminate the need for a navigator in aircraft. Similar solutions are proposed by the Americans for VOR/DME techniques based on polar coordinates. *Electronic computers* of various kinds undertake a variety of tasks, in particular in military airborne equipment, performing them in a manner and at a speed of evaluation impossible to a human crew.

Rotating antenna of RCA's AVQ-10 airborne radar in the nose of a Convair *Metropolitan*.

List of radar frequency bands
(according to Hewlett & Packard)
Centimetre and Millimetre waves

Band	Frequency range (mc/s)
S	2,600 — 3,950
G	3,950 — 5,850
C	4,900 — 7,050
J	5,300 — 8,200
H	7,050 — 10,000
X	8,200 — 12,400
M	10,000 — 15,000
P	12,400 — 18,000
N	15,000 — 22,000
K	18,000 — 26,500
Q	22,000 — 33,000
R	26,500 — 40,000

Radio navigation

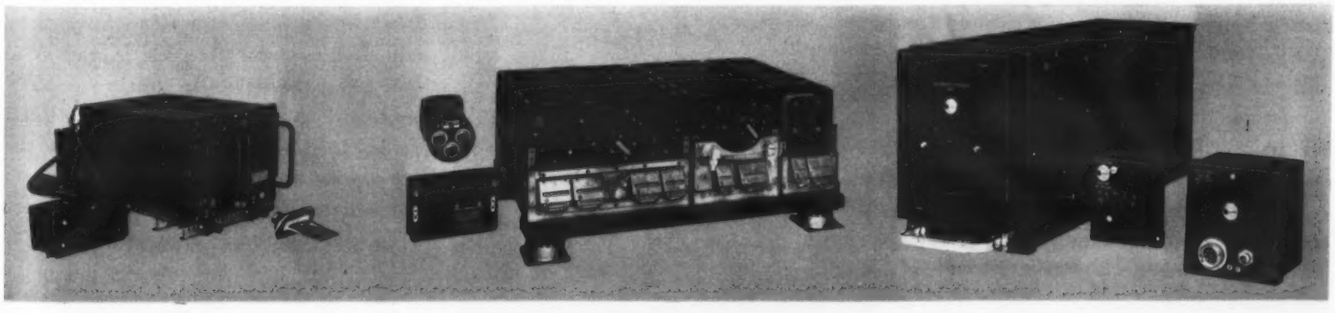
For position fixing a whole series of systems, discussed in *Interavia* No. 7, 1956, have been developed. Polar and hyperbolic systems continue to compete for first place in the three big domains of long distance, medium distance and landing. The decisive factor will ultimately be which system can *automatically* transmit the position data obtained on board in the simplest manner to Air Traffic Control on the ground, along with an identification of the aircraft and information on altitude. The constant growth in traffic and increase in speed render the solution of the problem of presenting traffic controllers with continuous, readily-grasped information on aircraft movements of the highest urgency. The present system whereby pilots are obliged to report by R/T on flying over given points on the airways must be replaced as soon as possible by a continuous automatic process. Otherwise the time-consuming transmission of reports and their evaluation on the ground will very soon set a limit to continued intensification of traffic.

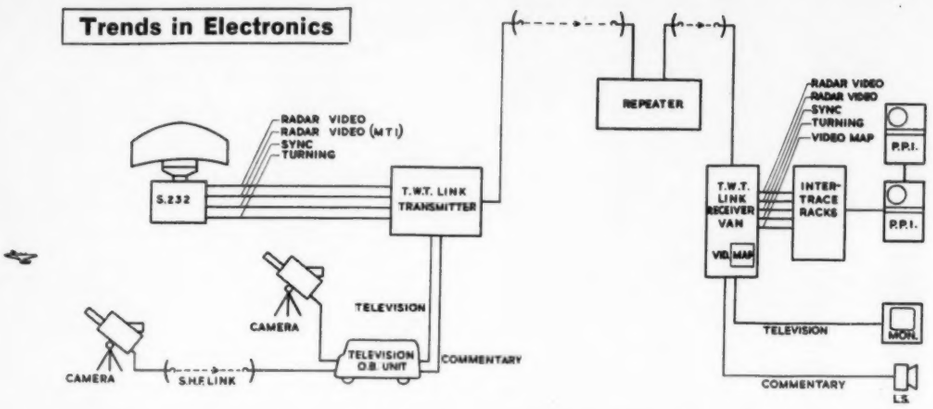
Certain long-distance routes, particularly across the Atlantic, have already reached a traffic density comparable to that on short-distance continental routes a few years ago. The utilization of the most favourable winds and most rational altitudes for jet aircraft will lead, here too, to a concentration of traffic, so that a *substantial increase in navigational accuracy* and the *provision of anti-collision equipment* are becoming an urgent necessity.

On medium-stage routes the problem is even more urgent. Unless provision is made for parallel flights at the same altitude on a given airway, no further intensification of traffic can be permitted in certain regions. Here too, therefore, the accuracy of navigation systems must be substantially improved and a system of *distance measurement*—of particular importance for jet aircraft—be introduced as soon as possible.

The British authorities have allowed for these circumstances by authorizing reduced longitudinal and lateral separation in the overcrowded London control area between aircraft equipped with Decca. The Americans plan to solve the same problem by building 400 new VOR stations, thus doubling the present number, and

Externally identical "black boxes" for very different uses; left to right, Cossor airborne transponder (for secondary airborne radar) with aerial the size of a child's hand; Standard (London) SR. 32 combined VOR/ILS receiver (back view); Marconi (Chelmsford) X. 2779 airborne radio teleprinter-receiver.





Special interest is being shown in the remote transmission of radar images. Diagram of Marconi's experimental installation for transmitting radar and television images from London Airport to Farnborough, some 20 miles distant. The installation works on four separate sub-carriers: two for radar images (bandwidth 1.25 mc/s each), one for the television picture (bandwidth 3.75 mc/s) and one for other information (bandwidth 0.5 mc/s).

by early introduction of DME for commercial aviation. The military prefer the TACAN system.

The Teleran system of televising to the aircraft the picture obtained on the ground radar screen appears to have been dropped as a navigation aid because of its extremely high cost.

The bottleneck in air transport is undoubtedly still in the landing process, since even today only one take-off and landing runway, even at large airports, can be used at a time, especially in bad weather. In order to get the constantly increasing traffic through this bottleneck it is essential to increase the landing rate. For this purpose the Americans propose the *coupling of ILS data with the autopilot*, while the British place their hopes on an *improvement in GCA technique*. Every baulked landing approach, in particular in bad weather, upsets an airport's whole finely calculated timetable. Hence everything possible must be done to reduce the number of baulked approaches to a minimum, perhaps even by additional aids as the A.C. leader cable system recently resurrected by the British and recommended in a lecture by Sir Arnold Hall.

Communications

In order to overcome the *shortage of frequencies* the industry has produced constantly improving equipment with the distance between channels reduced to 50 kc/s, but this would seem to be the limit achievable for civil use. The air forces will be able to manage for some time with the existing R/T channels in the UHF band from 250 to 400 mc/s, but then the same difficulties will also arise here. The only way out is to increase R/T discipline and to *compress communications by coding*. The automatic transmission of position fixes mentioned earlier takes a few milliseconds if *coded*, but several full seconds if *spoken*.

A successful experiment has recently been made by B.O.A.C. and Trans Canada Airlines aircraft on trans-Atlantic flights with *radio teleprinters*—working on long waves—to transmit weather and navigation data.

For HF communications the *single sideband technique* (SSB) is coming increasingly to the fore, since it offers the following advantages: the opening up of new channels, as about half of the channel width can be economized; an improvement in intelligibility, due to elimination of the selective fading, so disturbing in this frequency range, occurring with normal double sideband modulation.

Selective calling of aircraft by a ground station is designed primarily to lighten the task of the pilot, who has hitherto had to follow the whole R/T traffic despite the fact that only a fraction of it applies to his aircraft.

Radar developments

The provision of a *radar surveillance network* completely covering densely-flown areas is needed in order to give Air Traffic Control a continuous picture of the situation on surveillance scopes. A primary requirement, however, is the introduction of airborne identification equipment to identify individual aircraft and report at any rate their altitude.

Mobile radar link receiver (Travelling Wave Tube Link Receiver Van) of Marconi's installation at Farnborough.

Even if it should be possible in future to present the condensed, coded position fixes of all commercial aircraft in readily intelligible form to the ground control station, the radar surveillance network will still retain its value, above all in covering those aircraft which cannot be expected to carry extensive radio equipment, such as sports aircraft. For military purposes, airspace surveillance, in some cases using large-area radar systems, will always be used.

Airborne storm-warning radar has already been mentioned. A number of important companies have developed equipment of this kind, though here too—as is the case with maritime radar's 3–cm and 10–cm band—it has still not been decided whether the 3.2–cm (X band)[1] or the 5.5–cm (C band)[2] is better for storm warning. Undoubtedly the recently-introduced ISO Echo Contour control offers particular advantages, since it enables the whole structure of storm clouds to be resolved, thus revealing the particularly dangerous zones of high turbulence.

To complete the picture mention should be made of the various *radar installations for special purposes*, such as giant radar equipment for research purposes, radar stations to track the satellites during the 1957–58 International Geophysical Year, and wind finding radar (Decca) to follow weather balloons.

Extremely high frequency radar enables the control tower to follow surface movements in bad visibility (e.g., the Decca Q band radar at London Airport).

In the purely military field there are *radar fire control equipments* for the anti-aircraft artillery and *airborne fire control radar for cannon and rockets*. The detection and tracking of long-range rockets also requires long-range high-performance radar.

Bandwidth compression for the rational transmission of radar pictures over long distances also comes into the field of aviation electronics.

*

This brief, doubtless incomplete, summary shows what a tremendous field is covered by aviation electronics. Much still remains to be done before the various technical committees' projects for ensuring satisfactory air traffic and airways control are put into practice. On the international level, too, much determination and understanding will be needed if decisions of universal validity are to be made.

[1] X band 9,350 mc/s
[2] C band 5,400 mc/s

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Around the World

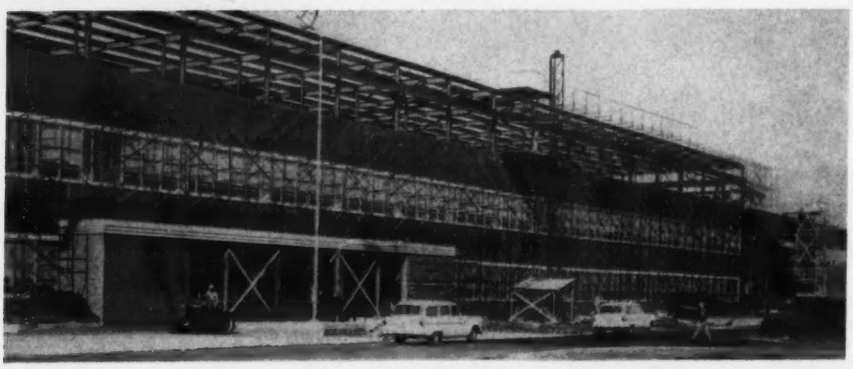
PRATT & WHITNEY AIRCRAFT division is expanding its branch plant at North Haven, pictured above, to a million square feet. Production for big turbojet engines is the principal activity here, as well as at the much larger Pratt & Whitney factory in East Hartford. This division builds turbojets, turboprop and piston engines, powering many different types of aircraft, both military and commercial.

ALMOST $213,000,000 of United Aircraft Corporation's own funds, spent in the last 10 years, stand behind the advanced aviation products—and those yet to come—manufactured by the Corporation's three divisions.

This unprecedented expenditure has been invested in construction of new experimental facilities and factory space, all in Connecticut. When complete, space will total 10,768,000 square feet, or about 250 acres, nearly three times as much area as was used in 1946.

Three new plants are pictured here. These are at North Haven, Windsor Locks, and Stratford. Large additions are being built at two of these plants to handle increased production.

Of the total, $80,600,000 were spent for research and experimental facilities, tools, and equipment. Included are the huge Willgoos Gas Turbine Laboratory, extensive laboratories at Hamilton Standard, and other installations necessary to assure continuing leadership in the power plant, propeller, equipment and helicopter fields.

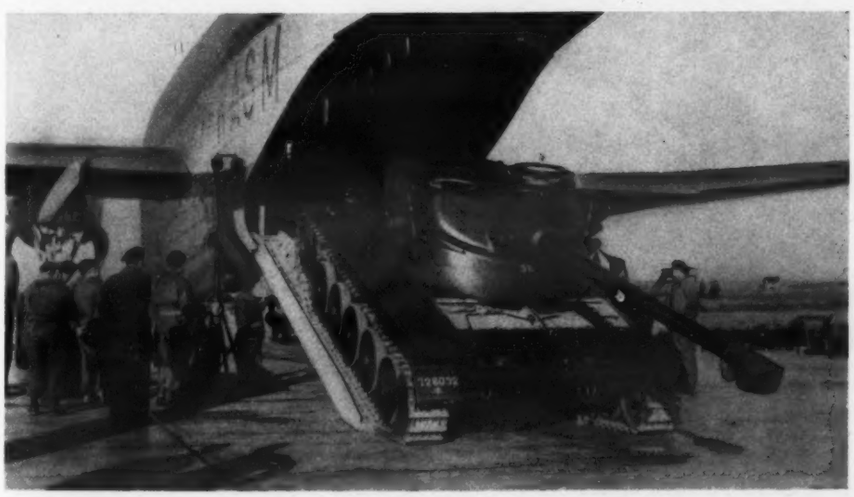


HAMILTON STANDARD division opened its new plant at Windsor Locks in 1952. Today, increasing propeller and jet equipment business requires additions totaling 400,000 square feet, part of which are shown here. The plant has extensive research facilities and a large branch at nearby Broad Brook.

SIKORSKY AIRCRAFT opened this huge new Stratford factory last year to handle production of S-55 and S-56 helicopters. Another plant in Bridgeport produces S-58 types. Facilities such as these help Sikorsky maintain its position as the world's foremost designer and manufacturer of helicopters.

with United Aircraft

CAA CERTIFIES S-58—Sikorsky Aircraft's big 12-passenger S-58 has been certified for commercial use by the Civil Aeronautics Administration, U.S. agency governing civil aviation. New York Airways, which operates helicopter mail, passenger and freight service, is the first commercial user to take delivery. The S-58 will carry a 2-ton payload 100 nautical miles, cruising at 100 m.p.h. It achieves the lowest ton/mile cost in helicopter history. A U.S. Army version of the S-58, an H-34, on July 12 set three closed course speed records for 100, 500 and 1000 kilometers. Record speeds, subject to confirmation by the Federation Aéronautique Internationale, are 141.9 m.p.h. for 100 kilometers, 136 m.p.h. for 500 kilometers and 132.6 m.p.h. for 1000 kilometers—all substantially higher than prior records.



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Hamilton Standard Hydromatic propellers have been selected for a fleet of Pratt & Whitney-powered Breguet 765 transports being built for the French Air Force. Blades are solid aluminum. The propellers, 16 feet in diameter, will have feathering and reversing features, fluid deicing and synchronizing. The Breguet 765, and 39 other basic types of civil and military aircraft, fly throughout the world with Hamilton Standard propellers.

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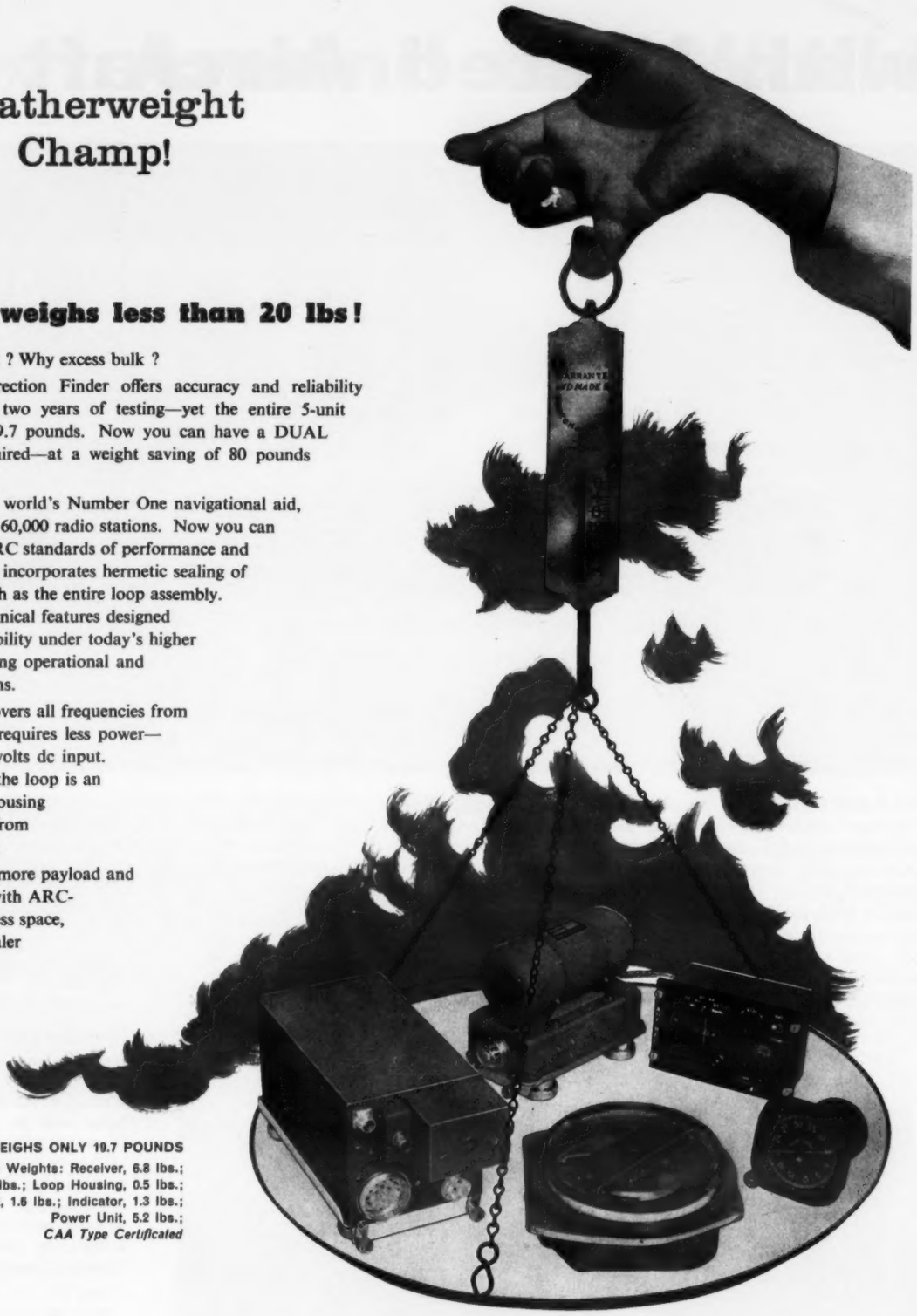

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Electronic Problems Encountered in High Speed Commercial Jet Aircraft[1]

By R. H. JEROME, Radio Systems Engineer, Douglas Aircraft Company, Inc., Santa Monica, California

Before discussing specific problems, it might be worthwhile to generalize on the overall aircraft electronics picture in commercial aircraft. An overwater version of the Douglas DC-8 may have electronic "black boxes" and indicators worth $140,000. The equipment may weigh in the order of 1,200 lbs., with another 1,200 lbs. of installation and wire weight. Between four and five miles of wire are used to interconnect the equipment and provide remote control. Approximately 26 so-called radio systems are controlled by switches, knobs, and dials located in the cockpit in such a way as to facilitate operation and observation.

The illustrations below are meant to show not only that there is a lot of electronic equipment aboard a modern airplane (and we are always getting more), but that the crew is seated in an environment of complication. It is somewhat amazing to think that the pilot can find the time not only to operate and monitor the controls and indicators, but to fly the airplane. Almost doubling the speed in jet aircraft means that the pilots have to accomplish their multitude of operations in almost half the time. This points out the need for simplification in indications and control. It means that the autopilot must take over a large part of the flying for the pilot, becoming a much more vital tool than it has been in the past.

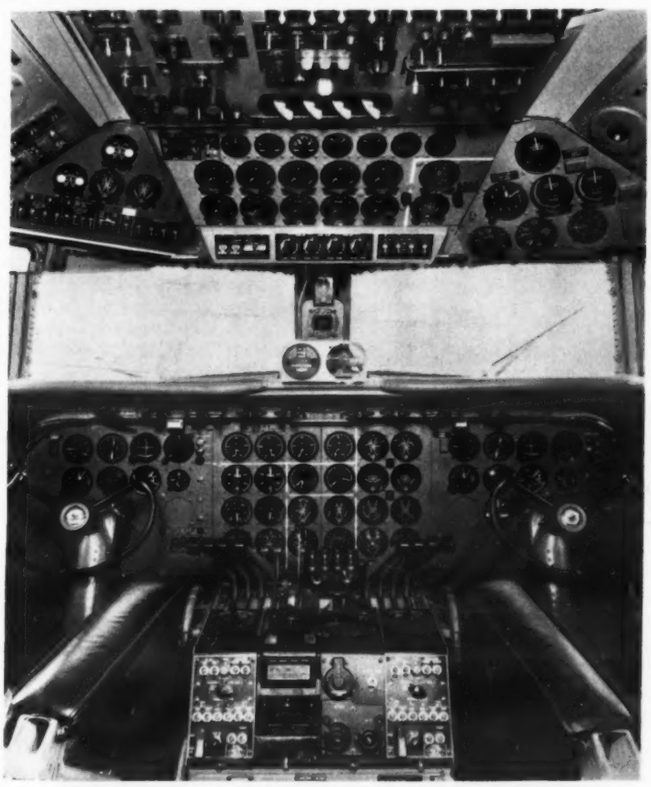
After the recent disastrous collision of airliners, it is apparent that the aircraft collision avoidance problem is a very real one. We all know that the airlanes are becoming overcrowded. With the advent of commercial jets, the problem will be more severe. Two jets approaching each other may have a closure rate of 1,200 m.p.h., or 10 miles in 30 seconds. By the time the pilot identifies the speck through his windshield as another airplane, little time remains for him to take any remedial action that may be required.

The most apparent solution is to design a system to provide a visual and/or aural signal if another airplane comes within a certain "protected volume" around the first airplane. This is a proximity warning system. The dimensions of this protected volume should extend further forward than aft and have the smallest dimension above and below the airplane to provide the pilot with sufficient time to locate the trespasser and take action if required, and not so great a volume that it would provide an alarm when not needed. This is important, because too many unnecessary alarms help only to make pilots nervous and detract from the usefulness of the device. In terminal areas, due to traffic congestion, the protected volume should be reduced in size to eliminate unnecessary alarms.

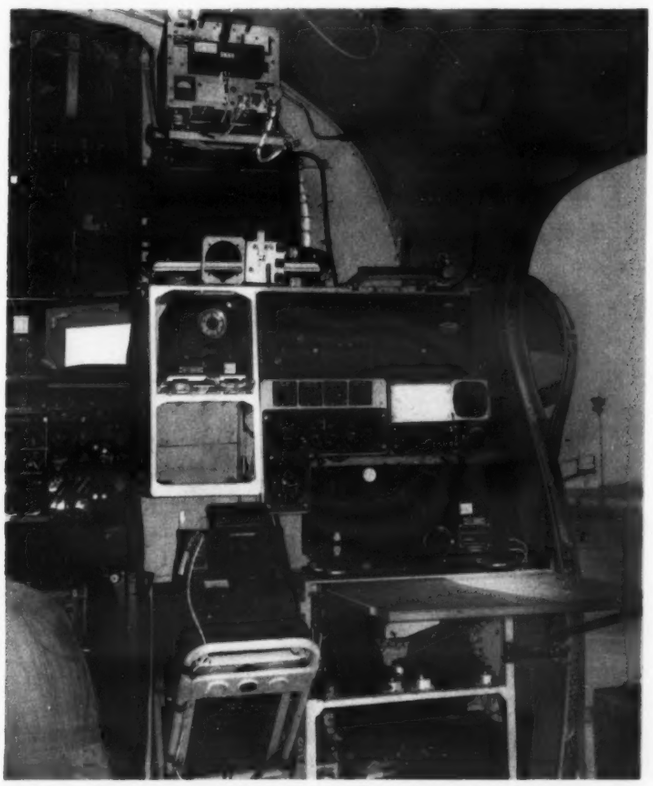
In addition to knowing that there is another airplane nearby, it would be advantageous to know where it is and, better yet, how to maneuver to avoid him. The final goal is not to tell the pilot that someone is near him, but to tell him that he is on a collision course and how to avoid the collision. This is *collision* warning as opposed to *proximity* warning.

[1] Paper read at The Western Electronics Show and Convention, August 24, 1956.

There is still just room for the pilots among the countless instruments in a modern commercial transport: the pilots' cockpit of a Scandinavian Airlines System Douglas DC-7C.



A similar "environment of complication" reigns in the navigator's post of the same S.A.S. DC-7C: Loran receiver, two ADF sets, two Polar Path gyros, various communications equipment.



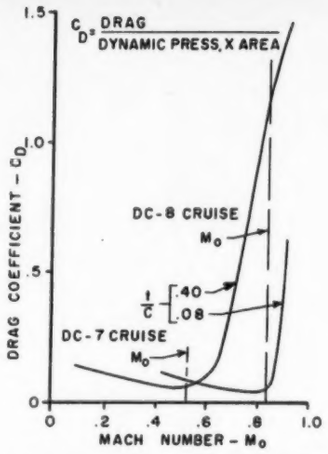
Could this system be connected to the autopilot? Should it be self-contained or a cooperative system? Is it possible to build such a system? Is rigid air traffic control the answer? If all of the present airliners in the U.S.A. (approximately 2,000) were equipped with a cooperative system, how about the other 140,000 private and military aircraft? Qualified technical personnel are now seeking these answers.

*

Another problem is the proper design of antenna systems for a jet airliner. It is obvious that as the speed of the airplane increases, the less desirable from an aerodynamic standpoint are the external wires, masts, and the blades employed as antennas in present airplanes. It is not so obvious from an overall airplane system standpoint, however, just how undesirable these antennas are. Each antenna requirement must be examined to determine how best to optimize radiation pattern efficiency, minimize loss in the antenna and the antenna lead-in, minimize aerodynamic drag, and minimize the antenna component weight.

Minimizing losses involves the basic antenna element design, including dielectric materials, and the loss in the coaxial cable lead-in. The loss in the coaxial cables becomes more important as the size of the airplane increases. To reduce the attendant loss in very long cable runs, Douglas initiated the development of a low-loss coaxial cable approximately two years ago. This cable minimizes system loss, enabling the antennas to be installed in their optimum locations and the equipment to be installed in the radio rack.

Reducing aerodynamic drag and antenna weight are inseparable problems. Flush antennas are usually heavier than external antennas, but their weight must be compared to the parasitic aerodynamic drag of the external antennas. The effect of drag must be analyzed in the light of the intended operation of the aircraft. Knowing the speed of the airplane and whether it is weight-limited or space-limited in its operation, a figure can be arrived at to equate drag to weight. A general overall comparison for the DC-8 shows one square foot of parasitic drag area[2] to be equivalent to 1,200 lbs. This figure, once established, guides the antenna designer in determining the relative merits of a flush and external antenna.



Effect of Mach number on parasitic drag coefficient for two antenna masts of the same frontal area with a thickness ratio (t/c) of 40 % (left-hand curve) and 8 %. Broken lines indicate the cruising speeds of the DC-7 and DC-8.

This weight-drag figure may not be alarmingly higher than that for a conventional aircraft; the real difference is that the same external antenna will have a higher parasitic drag as the Mach number is increased and, consequently, a higher drag equivalent weight. One of the figures shows the variation of drag with Mach number for an external mast of different thickness ratios. It can be seen that the drag is increased by a factor of 20 if a mast with a thickness ratio of 0.40, which is satisfactory for DC-7 cruise speeds, were to be used on the DC-8. Thus, most of our presently available external antennas present a large amount of drag weight at high speeds.

To compare this drag weight with the weight of a flush antenna, let us consider a specific example—a VHF communication antenna. The installed weight of a flush antenna mounted in the fuselage may be as much as 45 lbs.; it may be approximately 45 inches in diameter, and it may protrude through the floor of the baggage compartment. In this particular case, all three factors make the flush antenna look like a poor choice. However, an analysis of the Collins 37R-1 VHF Antenna shows that it has an antenna plus installation weight of 5 lbs., plus a parasitic drag weight of 48 lbs. giving a total equivalent weight of 53 lbs. Since the equivalent weight of both the flush and available external antenna would be high, we designed an external antenna which was much better from a drag standpoint at the DC-8 Mach number than the Collins 37R-1. The antenna we have developed has an actual weight of 3 lbs. plus a drag weight of 11 lbs. for a total of 14 lbs. In this particular case, an external antenna imposed the smallest penalty on the airplane. In most of the other cases, we have found that flush antennas are more desirable. Each antenna requirement must be carefully analyzed to determine the best solution. Of the twenty possible antennas on the DC-8, only three will be external and two will be semi-flush. In the latter case, an external fairing is placed around the antennas to reduce the drag.

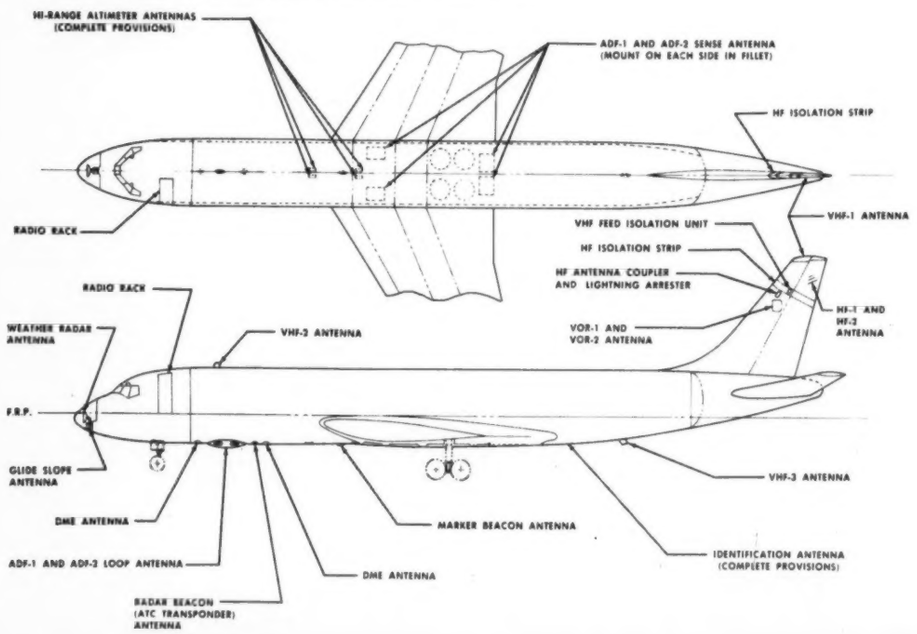
[2] The parasitic drag area is the drag divided by the free stream dynamic pressure, and is roughly (but not exactly) equal to the area of a flat plate producing an equivalent drag.

Now I would like to mention an old subject —precipitation static—which has many ramifications. When an airplane flies through a region of precipitation, it picks up a static charge. If this charge is high enough, it will cause corona discharge from points or sharp edges on the airframe, causing "static" in low, medium and high-frequency navigation and communications receivers. Propeller-driven aircraft have a number of static wicks (cotton-fiber impregnated with graphite) installed on the trailing edges of the wings and tail surfaces, providing a large number of very small points to discharge the aircraft at a continuous rate slow enough not to affect the receivers. How good a job the wicks perform is a debatable subject. They postpone the time at which unwanted corona appears, but a charge larger than can be handled by the wicks still causes noise. Ageing also reduces the wick's ability to perform its job.

I should now mention very briefly two problems due to increased altitude. One is cockpit brightness levels. At high altitudes, there are fewer diffractive materials in the air, and the illumination of the cockpit will therefore be lower. (Most of the light entering the cockpit is diffused light, not direct sunlight.) External objects, such as clouds, however, appear brighter because of the higher illumination level. This produces a greater brightness ratio between the work field and the surroundings, and means that the pilot has more difficulty in reading his instruments. On high altitude aircraft it is therefore necessary to determine the types and methods of using artificial light for reducing these brightness ratios without introducing new problems of undesirable reflections and shadows.

The second problem due to altitude is the unavailibility of a usable high range radio altimeter. The only available altimeter will have questionable ability above 25,000 feet; it is difficult to install, and has a cathode ray tube indicator not designed for use in the pilots' instrument panel. This problem has been recognized for a long time, but no equipment manufacturer wanted to build a new altimeter because of its limited commercial market—unless, of course, someone like the Air Force were willing to pay for its development.

"Of the twenty possible antennas on the DC-8, only three will be external and two will be semi-flush. In the latter case, an external fairing is placed around the antennas to reduce the drag."



The Eifel Radio Astronomy and Basic Radar Research Station

By Professor LEO BRANDT, Düsseldorf

The author of the following article is already well known to *Interavia* readers, who will remember his "German Radiolocation in Retrospect" in No. 6, 1950. As development chief for the firm of Telefunken during the war, he was responsible for the development of the *Würzburg-Riese*, *Lichtenstein* and *Egerland* radar equipments. In 1942 General Fellgiebel (executed after July 20th, 1944) gave him technical responsibility for Germany's entire radar development.

During the past few years the radar specialist has grown into an internationally known personality. *Professor Leo Brandt*, Under-Secretary of State in North Rhine-Westphalia's Ministry of Economy and Transport, has set himself the task of giving German research a new impetus. He was the prime mover behind the renaissance of the Deutsche Versuchsanstalt für Luftfahrt and has inspired many efforts and successes in the most varied branches of research. He has sponsored 25 German research and scientific institutes.

Though he is Chairman of the Deutsche Lufthansa Board's Technical Committee and Deputy Chairman—with Nobel prize-winner Otto Hahn, the discoverer of uranium fission—of the German Atomic Commission, his first love remains his old field of radar engineering. Editors

During the early post-war years Germany was prohibited from engaging in certain important fields of technical development, including in particular aeronautical and radar engineering. So as not to lose contact entirely, the authorities had to find ways of employing specialist personnel and tackling tasks of basic importance for future developments, while remaining within the framework of what was permitted them.

On the basis of these arguments I proposed to the Government of North Rhine-Westphalia about four years ago that it should set up an experimental radio astronomy station which could later be expanded into a general research centre for radar problems. In this way nearly all the specialists who had worked on the giant *Würzburg-Riese* radar equipment during the war were gathered together again. Thus the station on Stockert Berg in the Eifel hills forms a continuation of earlier development work by German radar engineers. With its reflector diameter of 82 ft. (compared with the *Riese's* 24.6 ft.) the new radio telescope proves that the reactivated German radar industry should also be equal to its future tasks in other branches, in particular in air traffic control and anti-aircraft warning.

*

That the sun emits an electromagnetic radiation which is received as "noise" in the radar receiver was first realized during World War II. Earlier (1931) *Jansky* had observed an electromagnetic radiation from the universe, and today it is known that there is a very large number of extra-terrestrial objects which radiate electromagnetic energy in the wave band between 1 cm and 30 m.

A special position in this broad frequency range is occupied by the 21 cm radiation which originates from interstellar hydrogen. As *Van de Holst* predicted theoretically in 1945, this radiation is the *1,420.405 mc/s spectral line* which is broadened into a noise band by hydrogen clouds and other influences. The frequency and amplitude behaviour of this noise enables important conclusions to be drawn on the structure of the Milky Way system.

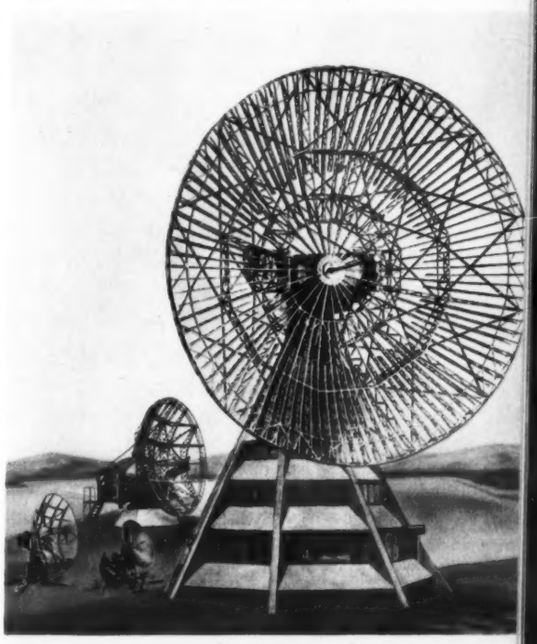
The full future significance of the research now undertaken cannot yet be predicted. However, it is worthy of mention that early this year President Eisenhower supported a proposal that the National Science Foundation should get $7,000,000 in the coming year for the construction of a radio astronomy centre. On page 794 is a list, not guaranteed to be exhaustive, of present and projected radio telescopes with movable aerial reflectors.

Thus a radio telescope of high efficiency, attached to the University of Bonn Observatory, has now been set up on Stockert near Münstereifel. It was formally inaugurated by North Rhine-Westphalia Prime Minister Fritz Steinhoff in mid-September, having been built for the North Rhine-Westphalia Ministry of Economy and Transport by an industrial group under the technical leadership of Telefunken, with the particular cooperation of the firms of AEG, Alkett and Metallwerk Friedrichshafen.

The reflector of the radio telescope—as radio astronomical equipment is now called—resembles a radar aerial *(fig. 1)*. The very large diameter of 82 ft. was chosen so that the equipment should provide the required resolution of the space observed; the latter, however, is still far removed from the sharpness of optical resolution.

Unlike radar equipment, a radio telescope does not generally emit energy, but is a pure

Fig. 1: The German *Würzburg*, *Ansbach* and *Riese* radar equipments compared with the radio telescope.



Radio telescopes with movable aerials, in operation or under construction

Site	Reflector diameter (ft)	Remarks
United Kingdom		
University of Manchester	246	Reflector swivelling in azimuth; under construction
Jodrell Bank	20—35	Several installations in operation
Various	26	Several installations in operation
United States		
Harvard University	65	Parallactic mounting; completed in April 1956
Harvard University	26	In operation
Naval Research Laboratory	52	Azimuth mounting; in operation
California Inst. of Technology	100	2 installations scheduled for 1957
California Inst. of Technology	33	In operation
Cornell University	26	In operation
Carnegie Institution	26	In operation
Bureau of Standards	26	In operation
Netherlands		
Kootwijk Radio Observatory	82	Azimuth mounting; completed
Kootwijk Radio Observatory	26	2 installations in operation
Australia		
Radio Physics Laboratory	210—260	Projected
Radio Physics Laboratory	23—40	Several installations in operation
France		
Various	23 and 40	In operation
Germany		
Stockert Radio Observatory	82	Azimuth mounting; completed

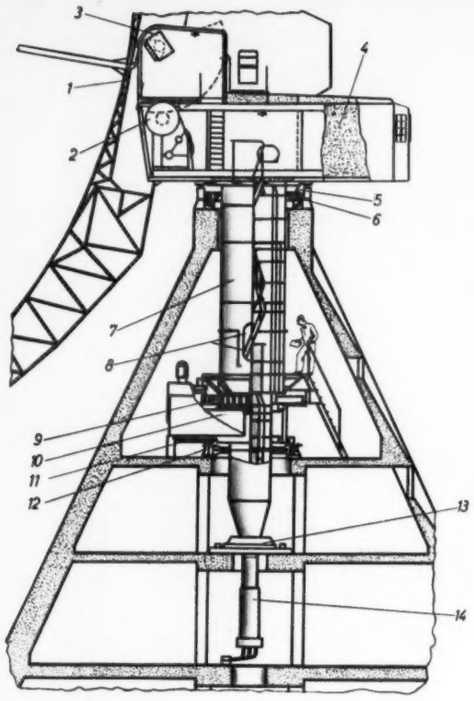


Fig. 2: Section through the radio telescope:

1	reflector	4	counterweights
2	tilting gear	5	hydraulic hoist
3	high frequency equipment	6	main bearing
		7	rotating column

receiving apparatus. However, it is planned later to use the Stockert radio telescope also for basic radar research. Consequently provision has been made for the installation of transmitters of various frequencies, together with the appropriate receivers. The building is so designed that radio astronomy and radar research groups can work independently, taking turns at using the reflector. The prime object of the radio telescope, however, is of an astronomic nature and consists in the investigation of the 21-cm radiation from the Milky Way.

The radio telescope has several interesting features from the structural point of view, including in particular high mechanical accuracy. Despite its 82-ft. diameter, for example, the reflector has a maximum deviation of only 5 mm from the ideal paraboloid *(fig. 3)*. It was designed and built by Metallwerk Friedrichshafen, a successor to the former Zeppelin-Werke which made all the *Würzburg-Riese* reflectors. With the exception of the roughly 40-ft. diameter steel ring, it is built entirely of light metal and lined with perforated light metal sheet, and weighs a total of roughly 20 tons. In high wind and with the reflector in the most unfavourable position, the mounting must support a wind pressure of approx. 54 tons. Perforated sheet reduces wind pressure only slightly (by about 20%), but does help to keep down the heat concentrated at the reflector's focal point in sunshine. Heat is also reduced by the electro-oxydation of the surface of the perforated sheet, as the roughness thus caused disperses the light and heat rays (whose wavelength is relatively short).

The reflector's mounting and drive mechanism *(fig. 2)* were designed with particular care. A hollow vertical axle—the rotation column—is let into a main bearing at the top of a pyramidal concrete tower. The lower end of the hollow shaft is connected to a cruciform sled so that the axis of rotation can at all times be adjusted to the true vertical. This is of particular importance since the Eifel is an old volcanic region, and ground movements are to be expected at the radio telescope's site. Provision has also been made for the reflector's tilting axis to be set exactly perpendicular to the axis of rotation by optical means. These arrangements meet the main requirement for an exactly definable mounting. Angular settings—azimuth and elevation—are read from selsyn systems in the control room.

Dimensions of the equipment as a whole have been chosen so as to ensure that any flexure due to its own weight, wind pressure or snow loads is extremely small. Special care was given to the manufacture of the driving wheels. For example, the main toothed wheel, with a diameter of approx. 10 ft., has a spacing error of less than 0.008 mm between two adjacent teeth and less than 0.03 mm between any two teeth.

The constant moving of so large a reflector in elevation and azimuth requires an efficient

Fig. 3: The radio telescope's paraboloid reflector (diameter 82 ft.) during final assembly on site.

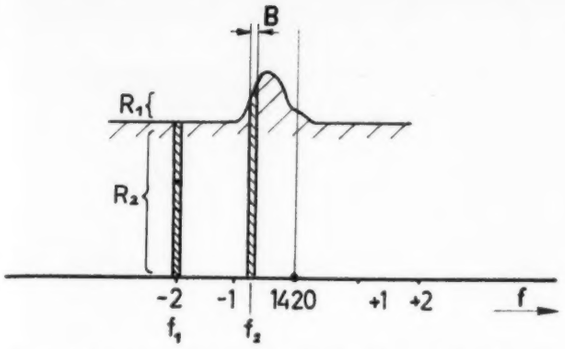


Fig. 4: The diagram of the reception principle for 21-cm radiation reveals the slight difference in intensity between signal noise (R_1) and receiver noise (R_2). B = intermediate frequency band width; f_1 = variable receiver frequency (mc/s); f_2 = fixed receiver frequency (mc/s).

Fig. 5: The radio telescope's receiver (without high frequency portion).

servo system, consisting of selsyn transmitters and receivers, electronic amplifiers and rotating amplifier machines (amplidynes). Three selsyn systems each (coarse, medium and fine) are incorporated for elevation and azimuth to ensure maximum accuracy in setting and reading. When making measurements for astronomical purposes the equipment must be so steered that it remains constantly directed at the same point of the firmament despite the earth's rotation. The rotating and tilting movements required are calculated by a mechanical analogue computer and introduced into the servo control system as a "programme".

When used for radar purposes, the reflector can be controlled, either manually or automatically, to follow its target, using the same servo technique and the indications of the acquisition equipment.

The concrete structure carrying the radio telescope is of pyramidal shape, as this ensures a particularly small displacement of the tip due to wind forces etc... by only 0.6 mm in the most unfavourable case. The concrete structure also has the advantage of high heat inertia, so that the sun's radiation causes little tension in the building. In order to reduce heat absorption still further, the eight load-bearing pillars were treated with a white coating which reflects a large proportion of the heat rays.

The electronic equipment comprises at the moment only a receiver for 21-cm radiation; equipment for radar research will be installed later. As the radiation to be captured, a "selective noise", lies well below the noise level of a good receiver—the maximum of the radiation to be received is about 2% of the receiver's own noise—the level investigated is compared in rapid succession with the noise level of a frequency a few megacycles distant *(fig. 4)*. The difference between the two reception energies appears at the receiver output as a modulation. After rectification and introduction of a large time constant (such as 100 seconds) the result is automatically recorded. The whole frequency range is passed through by means of a progressive switch device, while the recorder plots the energy received against the frequency. The complete investigation takes from two to seven hours, depending on the distance between the spectral lines. The receiver *(fig. 5)* contains some 200 tubes; its high frequency portion is housed in a cabin behind the reflector.

The actual erection of the reflector was an interesting process. As it was almost impossible to check its accuracy once it was installed, it was first completely assembled, with the aperture upwards, in the workshop. Its rigidity was tested by means of horizontally acting forces equal to its weight, when it was found that deviations from the ideal paraboloid form remained within the required tolerance of 5 mm. The reflector was then dismantled and transported by twelve railway trucks to its ultimate site, where it was reassembled and lifted on to the building with the aid of two cranes *(figs. 6 and 7)*.

Fig. 6: Two cranes 121 ft. high, with 144-ft. lifting arms, hoist the reflector.

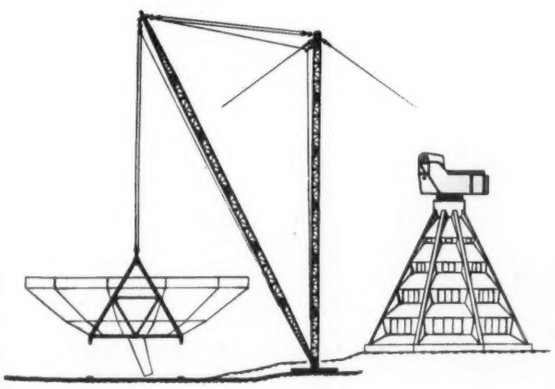
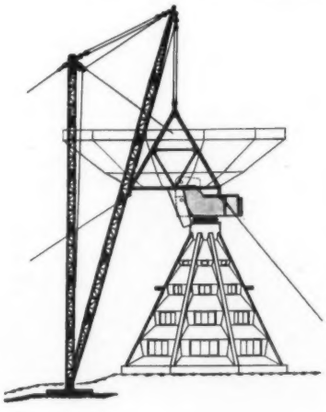


Fig. 7: The reflector is set in place on the tower (drawings by the firm of Krupp-Druckenmüller G.m.b.H., Berlin).



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Thus North Rhine-Westphalia, the biggest constituent state in the West German Federal Republic, which includes the Rhine/Ruhr industrial area, has constructed a radio telescope which will render valuable services not only to astronomy and cosmology but also to radar research.

Instructor for the Thousands

Ed Link and his Binghamton Works

Exactly twenty years ago the first production models of the Link *C Series Instrument Flying Trainer* made their entrance in the flying schools of the U.S.A. The carp-shaped rotating crates were then regarded as curiosities . . . and today they form part of the basic equipment of any instrument-flying school. Incidentally, those trainers of 1936 already possessed all the major characteristics which have since helped to train the crews of entire air fleets and all the commercial airlines in the world.

As the first picture shows, the instrument flying student takes his seat under the opaque hood covering the single-seater cockpit. He then swings the panel with the exact replicas of the major instruments—principally turn-and-bank indicator, clock, compass, air speed indicator and altimeter—and begins his practice. He operates throttles, control column and rudder pedals as if he were in a full-scale aircraft . . . but the crate actually performs only pitching, rolling and rotating movements. However, these motions suffice to enable the instructor, comfortably seated at a table, to correct the pupil in the trainer. With the aid of a "crab", a remote-controlled wheeled device tracing lines on a map spread over the table, he surveys the student's flight path. If necessary he gives the trainee advice and instructions by intercom.

Refinements of the C Series followed shortly. In particular, a remote indicating instrument panel was provided for the instructor, and new mechanisms were created to simulate wind drift and radio signals. These improvements resulted in the *D Series* (1937–38) and *E Series* (1939–40) Instrument Flying Trainer, succeeded by the C-3 and C-5 Trainers (1941). On trainers of the last-named models literally hundreds of thousands of air crew of all warfaring nations were trained during World War II. During the peak production period Link Aviation turned out trainers at the rate of one every forty-five minutes.

Edwin A. Link, creator of the Link Trainer and now Chairman of the Board of Directors and Director of Research of Link Aviation Inc., recalls that he first realized the idea of a synthetic trainer in 1929. He had always dreamed of building a trainer which could train pilots without leaving the ground. Just turned 24, pilot, aircraft mechanic and flight instructor, he built *Aviation Trainer No. 1* from baling wire, an electrically driven vacuum pump and the bellows of an organ in the basement of his father's organ factory at Binghamton, New York. The device rotated, moved all its control surfaces but had no hood and very few instruments. Intended to be a pre-flight trainer for absolutely raw students, Aviation Trainer No. 1 proved to be a resounding flop.

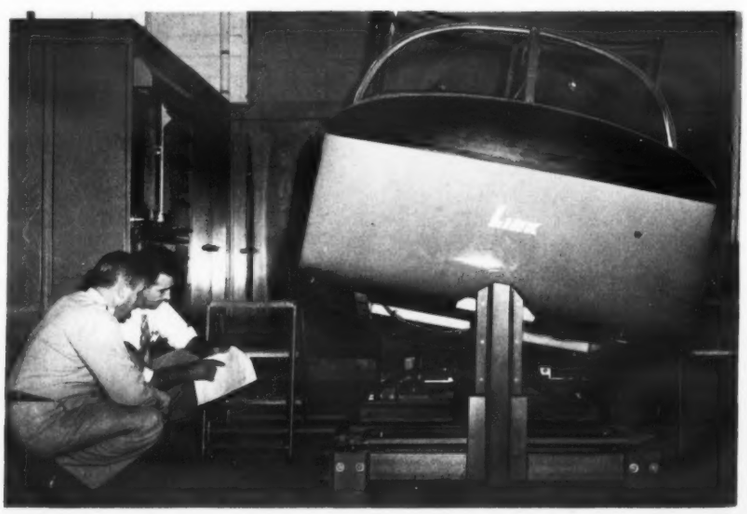
In 1930 Ed Link carted his invention on the back of an old Model T Ford truck from New York to the St. Louis Aircraft Show, where he was told that the thing was more suitable as a carnival stunt. In fact, he began to sell rides on it to recover some of his expenses.

Ed Link never lost courage, however. In the following years he developed the prototypes of his *A and B Series* trainers which were equipped with better instrumentation, an inter-communication system and a hood which enabled them to be used for instrument flying training. More than anyone else Link realized the importance of this feature, for he was a crack blind-flying pilot.

The break for which Ed Link had been waiting came in 1934. He was invited by the Army Air Corps to demonstrate his improved trainer to a group of officers at Newark Airport, New Jersey. Link had to fly in from Binghamton for the occasion and the day turned out to be very bad for flying—foggy and misty. In spite of the unfavourable conditions he got there, on instruments. This feat demonstrated to the officers that he was an authority on blind-flying, and shortly thereafter the (then) Army

One of the earliest Link instrument trainers, exported to Europe, here in service with the pre-war British Airways Ltd. This trainer was already equipped with remote-indicating instruments for the instructor. Across the instructor's desk crawls the characteristic "crab".

The modern (1955) Link ME-1 Jet Instrument Trainer for the training of the U.S.A.F.'s new pilots. The device no longer rotates about its vertical axis but can describe rolling and pitching movements.



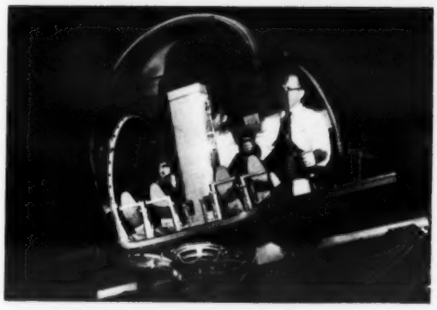
Air Corps ordered the first six Link instrument trainers.

Other orders followed, the company grew, and in 1940 the factory was moved to *Hillcrest,* about two miles north of Binghamton. By 1942 its payroll included 1,500 persons performing an important task.

The end of the war naturally brought heavy contract cancellations, but Link Aviation continued to develop new types of trainers in order to make up in quality for the losses it was incurring in quantity. Thus, in 1946 the first of the so-called *Operational Flight Trainers* simulating the characteristics of one specific aircraft was built. This was the F8F O.F.T. which reproduced the flight characteristics, cockpit and power plant features and radio equipment of the well-known Grumman F8F *Bearcat* naval fighter (Pratt & Whitney R-2800 engine). This was indeed a major advance. While all previous Link Trainers had been based on a "typical cockpit" and on average flying speeds, engine power, all-up weight brackets, the student pilot for the first time was now given a synthetic trainer which resembled the operational aircraft almost like one egg resembles another and thus made possible a substantial saving in training time.

At the same time the F8F trainer was in practice the last piston-engine fighter simulator. The jet age was coming, first represented by the land and carrier-based fighters, a few years later also by tactical and strategic bombers. In 1949 Link created the now famous *C-11 Jet Instrument Trainer* which generally simulates the characteristics of a *typical jet aircraft*[1]. More than 700 simulators of this type have so far been delivered. A little later the company turned out Operational Flight Trainers for the Douglas F3D *Skyknight* fighter (1951) and the Boeing B-47B *Stratojet* six-engined bomber (1952)[2]. It

[1] A brief description of this equipment appeared in *Interavia Review* No. 11, 1952, pp. 621 etc.: "Flight Simulators . . . Fly Like Aircraft".



The Link Helicopter Trainer simulates the operation of the Bell H-13 military helicopter.

Student and Instructor in the cockpit of the ME-1 Jet Instrument Trainer.

The costliest Link simulator is the D-2 High-Speed, High-Altitude Celestial Navigation Trainer which trains navigators for such tasks as trans-Arctic flying.

differs from the old-style rotating crates in that it is stationary.

Other Operational Flying Trainers have been developed in recent years for the Navy McDonnell F2H *Banshee* fighter (1953), the U.S.A.F. Northrop F-89D *Scorpion* fighter (1954) and the U.S.A.F. Convair F-102A supersonic delta-wing interceptor (1955). While the F-89D *Scorpion* ground training equipment already was very large, the F-102A simulator's size and space requirements surpass anything else in this domain (see *photo*). In spite of its importance the cockpit forms only a minor portion of the vast "laboratory". For the computers of this system, incidentally, Link changed over from alternating current to direct current for the first time, particularly to obtain higher precision and reliability, fidelity of simulation, extensive standardization of components and greater ease of maintenance.

It is clear that even a Service as opulent as the U.S.A.F. can afford simulators of the magnitude and complexity of the Link F-102A O.F.T. only in exceptional cases. For the basic training of its new pilots the U.S.A.F. has ordered the much smaller and cheaper *ME-1 Jet Instrument Trainer* in which Link reverts to the principle of the moving cockpit, at least for pitch and roll.

A similar method is used for the two-seater *Helicopter Trainer,* a more recent Link product, which is adapted to the Bell H-13 military helicopter and trains pilots chiefly in operating helicopters under *visual flight rules.* The trainer is equipped with an electronically controlled Compensated Offset Projection System (COP)

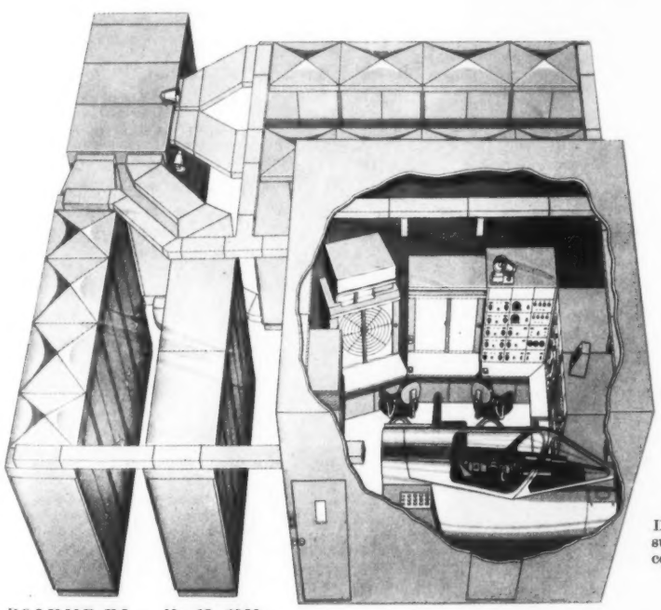


Diagram of the Convair F-102A supersonic delta-wing interceptor simulator.

[2] Also described in *Interavia Review,* No. 11, 1952 (p. 624).

and performs rolling and pitching movements up to inclinations of 13 degrees as well as rotating movements through 360 degrees. The terrain simulated in the light of the COP projector measures up to 250 sq. ft., depending upon the simulated height of the flight.

The costliest and most complex trainer built so far is the *D-2 High Speed, High Altitude Celestial Navigation Trainer* which resembles a medium-size planetarium, weighs about 20 tons and is said to have cost about three million dollars. It is described as the only trainer of its kind capable of simulating trans-Arctic flight and the astronomical constellations encountered on such flights.

For commercial pilots Link last year designed and built the *E-600 Professional Pilot's Procedures and Navigation Trainer* (Price $207,000 ex works) which duplicates a twin-engined medium-stage aircraft with a two-place cockpit, can simulate failure of one engine and contains all the usual radio telephony and navigation instruments. Furthermore, special trainers are now being built to simulate the Lockheed *Electra* turboprop airliner, the Boeing 707 and the Douglas DC-8 commercial jets. These trainers will sell for about $800,000 each.

Of special interest is the trainer now being developed for the DC-8. This will be available with or without a moving cockpit and can be additionally fitted with a *Telerama equipment* created by Douglas Aircraft Inc. *(photo)*. This "training moviehouse" operates as follows: in the vicinity of the trainer's cockpit a scale model of a selected airport, complete with instrument runway and taxi strips, is fixed vertically to the wall. Facing the scale model is a television camera capable of moving parallel and at right angles to the runway. The movements of its lens are controlled—via a computer—by the pilot's stick movements, so that its field of vision corresponds to the image which the pilot sees during a real-life approach. A projector mounted above the trainer cockpit projects the picture taken by the TV camera on to a 15-foot wide screen ahead of the cockpit windows. The light intensity of the screen picture can be dimmed in order to simulate visibility deteriorations. The Telerama system is a creation of Dr. W. B. Klemperer, Douglas research engineer (and well-known gliding pioneer).

Since 1953 E. A. Williford has been President of Link Aviation Incorporated.

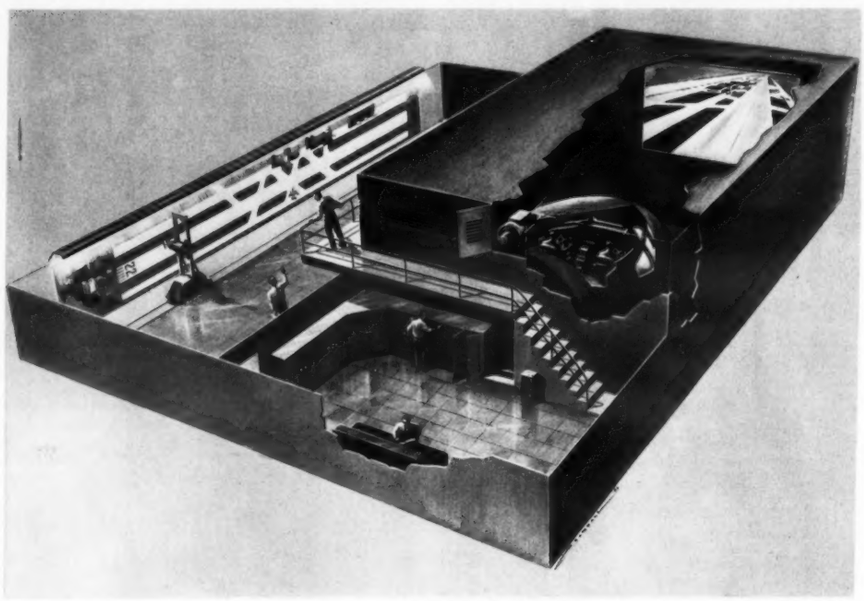


Diagram of Link's Douglas DC-8 trainer equipped with Douglas' Telerama system.

Link Aviation's main plant at Hillcrest, Binghamton, N.Y.

*

In conclusion it should be noted that in addition to simulators the Binghamton company manufactures a wide range of other electronic and precision mechanical products, for example its Aerolog Performance Computers and the "Fringecount" Micrometer. The latter operates with a light interferometer and is capable of making absolute measurements to within one-millionth of an inch.

In May 1954 Link Aviation Inc. affiliated with *General Precision Equipment Corporation* of New York City and thus became an important member of this family of seventeen[3] major companies manufacturing precision technological products. In the spring of 1956 Link acquired a controlling interest in *Air Trainers Ltd.*, Aylesbury, England, which for many years had been producing simulators, some of them under Link manufacturing rights.

[3] *Other major Link affiliates:* Ampro Corporation, Chicago Ill.; Askania Regulator Company, Chicago, Ill.; Bizzelle Cinema Supply Corp., New York City; General Precision Laboratory Inc., Pleasantville, N. Y.; The Hertner Electric Co., Cleveland, Ohio; Kearfott Company Inc., Little Falls, N. J.; Librascope Inc., Glendale, Calif.; J. E. McAuley Mfg. Co., Chicago, Ill.; National-Simplex-Bludworth Inc., New York City; Precision Technology Inc., Livermore, Calif.; The Strong Electric Corp., Toledo, Ohio.

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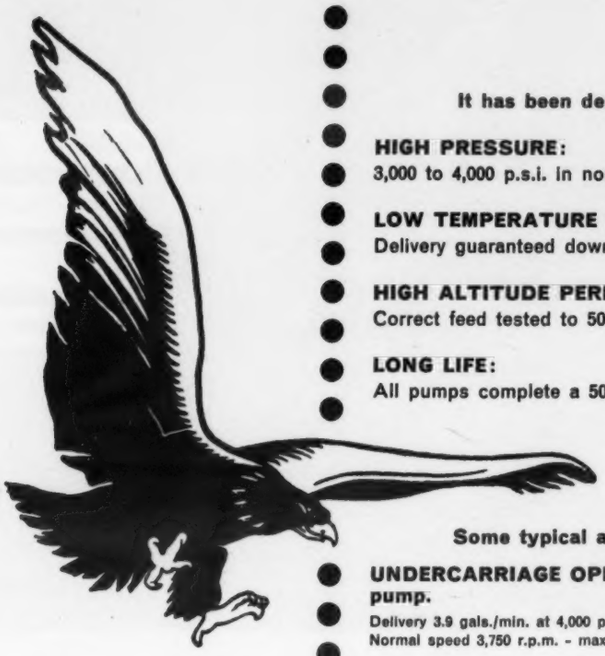

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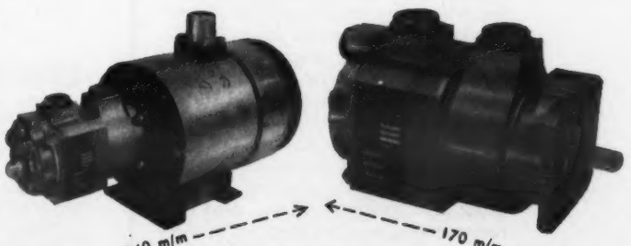

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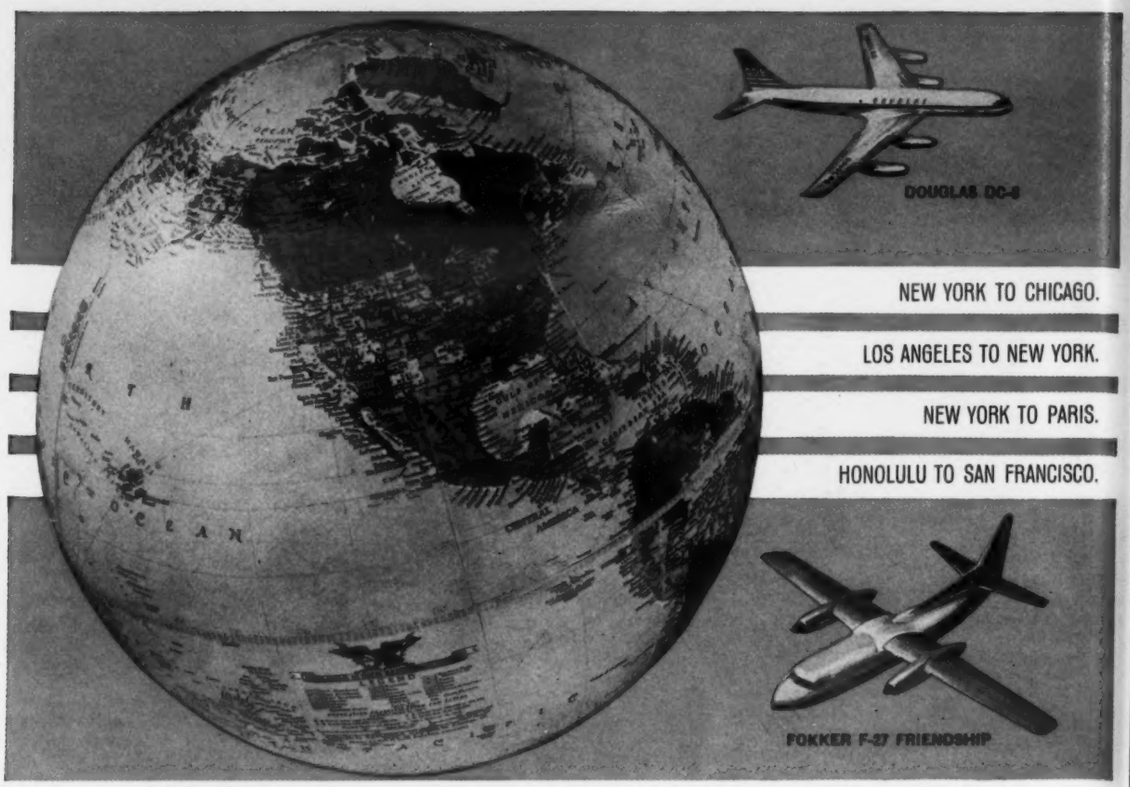

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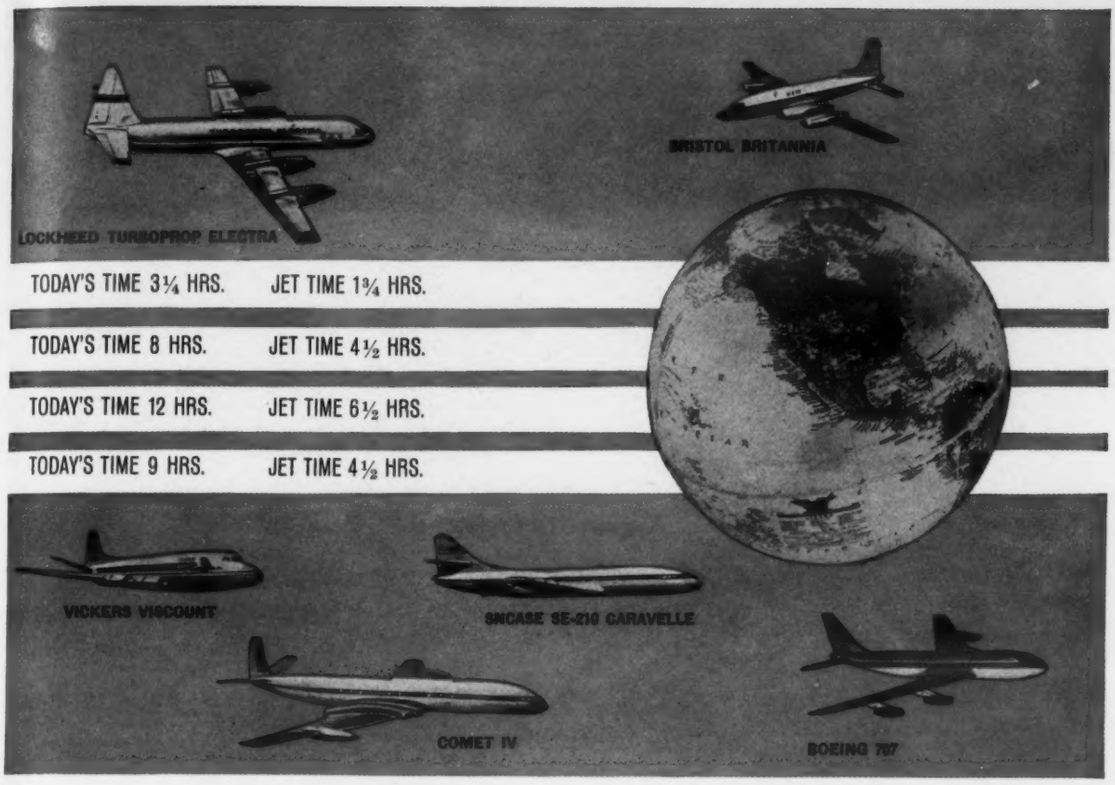
Automatic high-altitude oxygen system for passengers plus flight crew oxygen system.

SPECIAL INSTRUMENTS
To measure Mach airspeed and fuel flow; accelerometers; specially lighted turn-and-bank and rate-of-climb indicators.



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The Air Hostess Told Us...

Know what? says Esmeralda, annexing our chair and crossing her slender undercarriage; I've discovered that all things come to him (or her) that fights, and in future I shall be aggressive. Good grief, we groan at our Favourite Air Hostess, you're pure poison anyway, so why make it worse? I'll tell you why, she smiles. You will admit that French girls are among the most enlightened and progressive in the world. So what do they do? My colleagues with Air France clamour for nice clothes—and Air France just can't resist and supplies its hostesses with clothes that are voted the "most chic" by those uniform artists, the Americans. Then what happens? An American company, Allegheny Airlines, is completely overcome and invites a gaggle of fifteen of the loveliest Air France hostesses for six months to the United States as guest hostesses (a contradiction in terms) under a thing called "Project Lafayette". They're there right now, sighs Esmeralda, and I'm sure they're having a ripping time.

Here is another case in point, says our Favourite Air Hostess. A few weeks ago you told your patient readers that some airlines were introducing Kimonos for their Japanese air hostesses. The girls of Pan American and B.O.A.C. simply said "no soap", top P.A.A. officials took one look at the things and sent them back to the shop. B.O.A.C. paraded some Kimono-clad hostesses before the management in London who nearly fainted and voted the scheme out of existence. Round one to the hostesses, you see. And even the gentle Japan Air Lines hostesses made such a frightful ruckus that the J.A.L. top executives got together and devised a simpler Kimono with fewer cords and hidden knots in the "obi" or whatever you call that part of the garment which one wears around the stomach. See, asks Esmeralda, just scrap and you get what you want.

The J.A.L. girls are not alone, Esmeralda continues. Take the hostesses of Pakistan International Airlines. Initially they were told to put on that national dress of theirs and get on with the job. Very pretty, too, they replied in unison, but not very practical. Now they have got a compromise—a contraption which P.I.A. describes as a streamlined version of their national dress consisting of a green *Kamiz* over a white *shalwar* (pyjama pants to you) and a *dupatta* draped over the shoulders (see picture). Looks comfortable. And they also got gold earrings. You understand now, says our Favourite Air Hostess, why I want to continue the fight, carry the torch, etc.—we girls want to work in comfort. Work? we scoff, you don't work, you just fly around and look pretty.

Your cheek is stupendous, retorts Esmeralda, and I should not be on speaking terms with you. Air hostesses work much harder than journalists, as my recent ordeal will show you. In order to make us efficient in every branch of our activity, they organized—of all things—an international diaper changing derby at the Nikkatsu Hotel in Tokyo on August 16th. Contestants were American, Japanese and Chinese hostesses, plus myself, and our raw material consisted of a lot of diapers plus six odious, howling brats—two American, two Japanese, two Chinese. The prescribed methods of changing the diapers of the sweethearts were the American "three-corner pants" and "square" styles, the Japanese "treble strength" and "sumo" fashions and the Chinese "double diaper" and "belted longies", and every girl had to use one of each national method. Trophies were awarded for skill and speed, and the brats got prizes for the degree of their cooperation. It's a hard life.

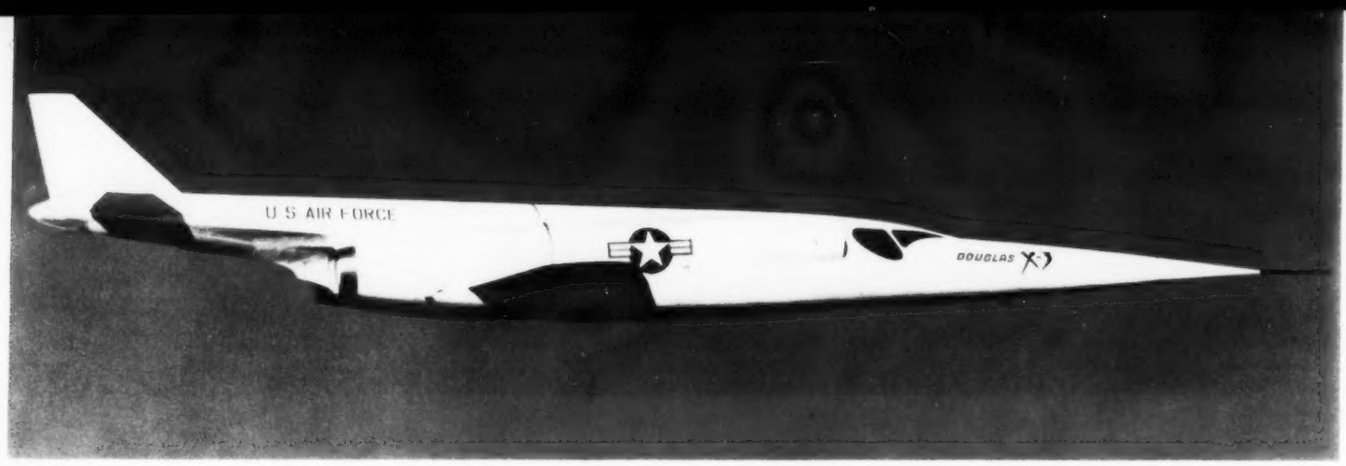
"Streamlined version of the national dress". P.I.A.'s streamlined air hostess, Miss Puntakhey.

How did you make out, we ask our Favourite Air Hostess. Not too well, personally, she says dreamily, but my babies got top marks for cooperation: you see, I chloroformed the darlings . . .

One never knows what things are good for, however, she continues. Look at this diaper training, for example. It would have been useful to the two hostesses aboard the T.W.A. airliner which turned back to New York on August 20th after six hours of Atlantic flying. Why... ? we venture. That should be obvious, she says, but if you don't know, I'll tell you. This aircraft was cruising along nicely when, about 920 miles out of New York a 38-year-old passenger bearing the name of Emilio Ordonez Urunuela began a strip-tease act and took off all his clothes. What did the hostesses do? They screamed for help, half of the male crew came rushing back into the cabin, forced Emilio back into his pants, and the pilot flew back to Idlewild. Now, says Esmeralda, had those hostesses known anything about diapers, one of them could have practised a judo double lock on him while the other was fitting him with diapers, "belted longies" or any style. Then, with Emilio suitably chloroformed, they could have flown on to Europe.

"Project Lafayette" – Allegheny Airlines' "guest hostesses".

The "obi" has been simplified.



The X Series of Research Aircraft

The first successful supersonic flights by the Bell X-1 rocket-powered experimental aircraft in October 1947 marked the beginning of the practical realization of an ambitious N.A.C.A. programme aimed primarily at investigating flight conditions at high altitudes and high Mach numbers by means of special research aircraft (class designation for "experimental" X). — Twelve years have now passed since the X-1, the first of these N.A.C.A. aircraft, took shape on the drawing board. Since then improved versions of the X-1 and new research aircraft have been developed, some of which reach speeds of more than 2,000 m.p.h. and altitudes above 80,000 ft. The tasks of the research programme have also changed. Whereas, initially, questions of drag and stability provided the only obstacles, new difficulties began to arise as speeds increased, namely the heat barrier and the limits of the pilot's physiological endurance. Nevertheless, new manned and unmanned experimental vehicles for speeds of up to Mach 5 and above are constantly being built (Douglas X-12, North American X-15 etc.) to investigate conditions at the edge of the earth's atmosphere. Of late research on structural materials (Lockheed X-17) and development of new electronic equipment (North American X-10) have been added to the N.A.C.A. programme. It is obvious that considerable funds are needed: whereas "only" $10,000,000 were spent on the design and construction of the X-1, the cost of the Douglas X-12 is reportedly several times this figure, and the X-12 is by no means the last of the X series. — The research programme, however, is of decisive importance to the United States' air armament. Its results indirectly benefit industry by providing the bases for detailed research. In addition, in many cases information of direct value in the design of new aircraft is obtained.

*

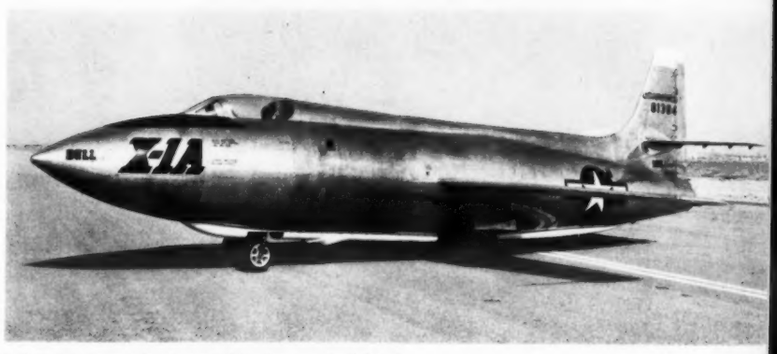
The story of the X series begins during the war, in 1944, when N.A.C.A. scientists realized that reliable wind tunnel measurements in the transonic range could not be made with the means then available. To fill this gap, the U.S. Air Force and Navy decided on the immediate construction of two research aircraft, the rocket-powered Bell X-1 and the jet-powered Douglas D-558-1. Both were designed on the principles of subsonic aerodynamics but were to be sufficiently strong to withstand all stresses at supersonic speeds and high altitudes. In addition they were to be kept as small as possible to enable them to reach transonic speeds in level flight despite the modest power of the reaction engines of that time. For this reason all military and a good proportion of standard equipment had to be eliminated, and only the essential instruments retained. As, at that time, there was no proven high-power turbojet available, the X-1, which was completed first, was fitted with a Reaction Motors Inc. E 6000-C4, with four barrels and a thrust of 6,000 lbs. Originally two turbine-driven fuel pumps were planned, but because of delays in the development of the steam producer (concentrated hydrogen superoxide with catalyser) for the turbine it was decided to use a much simpler pressure gas feed system, which also provided power to operate the flaps, undercarriage, gyro instruments and cabin pressurization system. The gas used was pressurized nitrogen, which was stored in a voluminous tank under a pressure of 5,000 p.s.i. and emptied the fuel and oxygen tanks when a valve was opened. This type of fuel feed, however, necessitated the use of pressure-tight tanks, thus considerably raising the total weight of the system—at the expense of the fuel. Altogether 288 gallons of liquid oxygen and 300 gallons of alcohol/water mixture (ratio 5 : 1) were carried, giving an endurance of 2.5 minutes at a consumption of 3.92 gallons per second (at full power). As the rocket engine's endurance was too short, even when the four barrels were ignited in succession, to make test flights from the ground, a four-engined B-29 was converted to carry the 31-ft. long X-1 in its extended bomb bay. The B-29 lifted the rocket aircraft up to a suitable altitude for release. After a number of gliding descents, the first powered flight was made on December 9th, 1946, and an October 14th, 1947 Major Charles Yeager (today Colonel) became the first pilot to exceed the speed of sound.

Each test flight in the X-1 was based on a detailed flight plan. During the initial climbing phase the pilot remained in the B-29 mother aircraft. On reaching roughly 10,000 ft. he climbed down a ladder—in the open air—into the X-1's confined cockpit, squeezing himself through a small door in the side of the fuselage. The same opening served as emergency exit. No ejection seat was fitted, and Yeager describes the parachute as probably having been designed primarily as a comfortable seat for the pilot. At 25,000 ft. the fuel tanks were placed under pressure, and at 30,000 ft.—after release—the few minutes' flight into the unknown began. On completion of the mission all remaining fuel was jettisoned, after which the pilot steered for the 13-mile dry lake-bed runway at Muroc which was used as operating base for the X-1. He flew over the runway at more than 300 m.p.h., turned at about 220 m.p.h. and touched down at 180 m.p.h.—three times the speed of an express train.

Mach number was increased from flight to flight only when flight behaviour had been fully investigated at lower speeds with increased lift coefficient. During the test series it was found that many aerodynamic phenomena which normally do not occur until high Mach numbers are reached also appeared at lower Mach numbers when flying with increased lift coefficient (banking with stick pulled back). In this way a careful

Attaching the X-2 to the B-50 mother aircraft, which is raised by hydraulic platforms.

Bell X-1, first of a series of rocket-powered research aircraft.



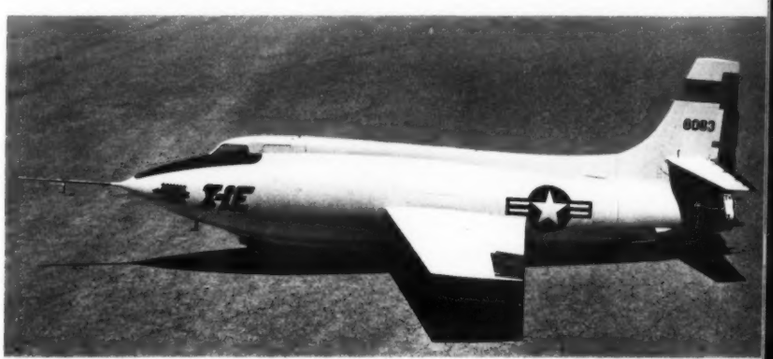
Bell X-1A : longer fuselage; fighter-type cockpit hood.

approach was made to Mach 1.5. As was to be expected, stability troubles appeared under certain conditions, but these were less serious in the straight-wing X-1 than in the swept-wing aircraft tested later (Douglas D-558-II, Northrop X-4, Bell X-5). With a thickness/chord ratio of 8% for the wing and 6% for the tailplane, the X-1's critical Mach number was roughly 0.88. The airframe was stressed for +18g and —10g, and no serious damage occured to the airframe throughout the tests. All aircraft of the X-1 series had direct control force transmission, with no power boosting.

The X-1 made its first ground take-off on January 7th, 1949, with tanks only part filled. It taxied slowly along the salt lake runway, its four rocket chambers snorting, gathered speed, took off after only 2,300 ft. and climbed to 23,000 ft. in 100 seconds.

Meanwhile two more X-1s had been built, one with a thickness/chord ratio of 10%, the other with the turbine-powered fuel pumps originally planned. Use of the hydrogen superoxide pump system enabled fuel capacity to be increased to 500 gallons of liquid oxygen and 550 gallons of alcohol/water mixture, which promised a theoretical endurance of 3½ minutes. However this aircraft exploded before release during its first test flight in November 1951.—The X-1 prototype is now in the Smithsonian Institution museum in Washington.

Bell X-1B : special measuring instruments to investigate the "heat barrier".



Bell X-1E : last member of the X-1 series, with wing of only 4% thickness/chord ratio and further modified cabin hood.

Bell X-2 : this rocket aircraft equipped with skid undercarriage is placed on a trolley for ground movements.

*

The experience gained with the first research aircraft was utilized in the later Bell X-1A, which was completed at the end of 1951 and immediately began works tests. Its main differences compared with its predecessor were its 7-ft. longer fuselage with modified cockpit (ejection seat) and set-on hood. The bigger fuselage enabled a larger fuel supply to be carried, so that endurances of more than 4 minutes were obtained.—The X-1A was delivered to Edwards Air Force Base in November 1953, and it was decided to try and reach Mach 2 by December 17th, the 50th anniversary of the Wright Brothers' first powered flight. The historic flight, during which Colonel Yeager raised the unofficial world speed record to Mach 2.5, actually took place on December 12th. After leaving the mother aircraft at 30,000 ft. he began a "routine" climb to 60,000 ft., then switched on the fourth rocket chamber and slowly pushed over into level flight, reaching Mach 1.9 at 78,000 ft. At this stage the aircraft was accelerating at 31 m.p.h. per second. Yeager then went into a shallow dive and attained Mach 2.5 or 1,650 m.p.h. at 76,000 ft. Up to this time the constant acceleration had maintained an "induced" stability, which vanished suddenly, however, when all four combustion chambers cut out simultaneously. The pilot immediately lost control of the aircraft, which tumbled wildly and recorded accelerations up to 11 g. Roughly 50 seconds later Yeager found himself at 25,000 ft. at only 170 m.p.h. indicated air speed, having used all his strength to recover from an inverted spin. The air forces on the fuselage sides reached two-and-a-half times the design limit, but the robust airframe withstood them. Colonel Yeager finally landed on Muroc, half stunned and badly bruised.—This was his last flight in the X-1A, as he was transferred to other duties. Later Major A. Murray took the aircraft to 90,000 ft. but remained below Mach 2.

At the beginning of 1955 another X-1A was completed, with new wings of only 4% thickness/chord ratio and an aspect ratio of 4 (compared with the earlier 6). Just before its first launching, while the mother aircraft was still climbing, its fuel system exploded and set it on fire, so that it had to be jettisoned.

Colonel Charles E. Yeager (left), until recently the "fastest" man in the world, greeting the "highest" man, Major Arthur Murray (90,000 ft. in the X-1A).

Colonel Frank K. Everest, chief of flight test at Edwards AFB, reached a speed of 2,500 m.p.h. in the X-2 on July 25th, 1956.

John H. Griffith, well-known N.A.C.A. test pilot, was responsible for test flying the Northrop X-4.

A few months before this incident the Bell X-1B was delivered. This was a development of the X-1A with special instrumentation for research into aerodynamic heating. Another member of the X-1 family, the X-1D, shared the fate of most of its predecessors: on August 21st, 1951 it was jettisoned from the B-50 mother aircraft after a fuel explosion. The last member of the straight-winged X-1 series is the X-1E, with again a modified fuselage and new-type hood whose sharp angled windshield recalls the Douglas D-552-II.

*

The primary object of the experimental flight programme is to determine the maximum performance of the aircraft used. However, it has proved scarcely less important—and somewhat difficult—to ascertain the maximum lift coefficient obtainable in practice at high Mach numbers. It has been found, for example, that in the region of the highest Mach number speed drops disproportionately when angle of attack is increased, so that tight turns can be made only at lower Mach numbers with the available engine thrust. Because of the tremendous rise in drag with merely a small rise in lift it was realized that for investigations of lift at high Mach numbers, for example Mach 2, an aircraft had to be used whose max. speed was well above this limit.

This requirement is met by the Bell X-2, whose rocket engine has sufficient surplus thrust to permit flight with high angle of attack at Mach numbers above 2. Though the X-2 project goes back to 1947, the first aircraft had to undergo numerous modifications after its completion in January 1950, so that delivery to the U.S. Air Force was delayed until the early summer of 1952. During a test flight in May the next year the X-2 cut adrift from its mother aircraft after an explosion and plunged—unmanned—into Lake Ontario. The second X-2 was completed shortly afterwards, and Bell began gliding tests in August 1954. The first flight under its own power (endurance 6 minutes) was made in November 1955 by Colonel Frank K. Everest, chief pilot at Edwards A.F.B. On July 25th, 1956 Everest reached the improbable speed of 2,500 m.p.h., which, however, has not been officially confirmed by the U.S. Air Force for security reasons.

The extremely small swept-wing X-2 differs in many respects from the X-1 series. The wing and tail are made of stainless steel, the fuselage of thick-walled nickel steel (K-monel sheet). The projected speed range for the X-2 makes the use of heat resistant alloys for all stressed parts imperative. Even at Mach 2 to 3 the skin heats up to 120°C to 350°C, despite low ambient temperatures at high altitudes (–50° to –60°C). Thus special temperature resistant glass was even needed for the sharp-angled cabin windows. Unlike the X-1, the cabin is heat-insulated and air-conditioned to a much higher inside pressure; controls are power-boosted. In an emergency, the whole cabin is separated from the fuselage by means of explosive bolts and drops on a ribbon parachute to a height at which the pilot can use his own parachute without danger. Power is supplied by a Curtiss-Wright LR-25CW-1 rocket motor of approx. 16,000 lbs. thrust, which can be continuously regulated by a single control lever. To save space the conventional twin-unit main undercarriage is replaced by a retractable skid and a nose wheel to control sliding on the ground.

*

Where are the wings . . . ? A hint of the shape of future supersonic aircraft is given by the twin-jet Douglas X-3.

One of the most unusual aircraft ever built is undoubtedly the *Douglas X-3*, the "flying pencil", with a length of 66 ft. 9 ins. and a span of only 22 ft. 8 ins. More than sixty projects with the most varied forms of propulsion were studied before the version with two Westinghouse jets was decided upon. The aircraft was completed in mid-1952 and, after extensive testing by Douglas pilot Bill Bridgeman, was handed over to the U.S.A.F. in December 1953. Needless to say, only the most skilful pilots can fly such a machine, with its wing loading of approx. 200 lbs./sq.ft. and landing speed of more than 215 m.p.h. No details have unfortunately been announced on the aims and results of the X-3's flight research programme, which has now been concluded.

*

Whereas the X aircraft so far described have been used primarily for investigations in the supersonic range, the jet-powered *Northrop X-4* and *Bell X-5* were designed expecially for research in the transonic range. It was therefore an obvious move to fit these two aircraft with swept

The *Northrop X-4* was used primarily for stability tests.

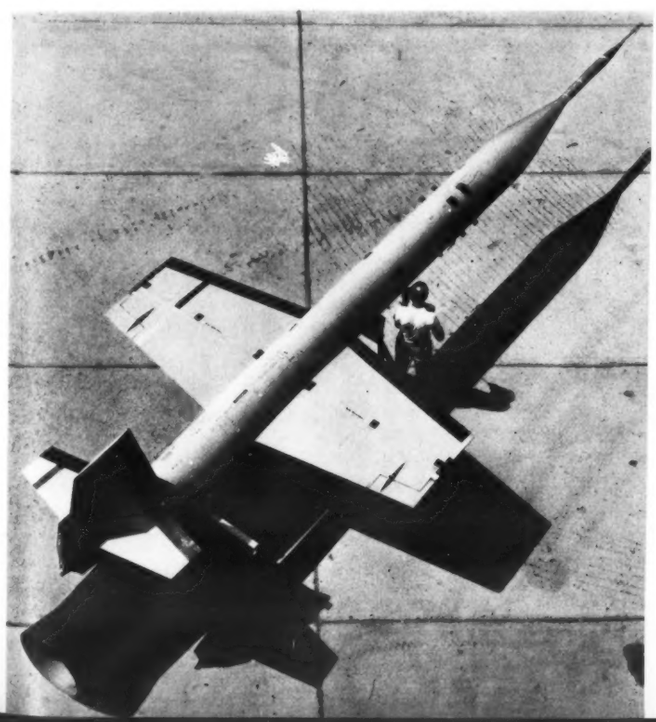
Bell X-5: variable-sweep wing.

Technical Data of U.S. Research Aircraft

Type	Span (ft. ins)	Length (ft. ins)	Gross weight (lbs)	Power Plant		Max. speed (m.p.h.)	Remarks
				Type	Thrust (lbs)		
Bell X-1	28' 0"	31' 0"	13,400	Reaction Motors E 6000-C4	6,000	1,000 at 60,000 ft.	Thickness/chord ratio 8%, weight empty 4,892 lbs
Bell X-1A	28' 0"	35' 7"	18,000	E 6000-C4	6,000	1,640 at 76,000 ft.	Thickness/chord ratio 8%, later 4%, weight empty 6,970 lbs
Bell X-1 B/D	28' 0"	35' 7"	18,000	E 6000-C4	6,000	—	Similar to X-1A, but with special measuring equipment
Bell X-1E	28' 0"	35' 7"	app. 18,300	E 6000-C4	6,000	—	Development of X-1A with 4% thickness/chord ratio
Bell X-2	25' 0"	40' 0"	app. 13,200	Curtiss Wright LR-25-CW-1	app. 16,000	2,500	Sharp-edged airfoil of extremely small thickness/chord ratio
Douglas X-3	22' 8"	66' 9"	app. 22,000	2 × Westinghouse J-40	7,500	—	Nose cooled by fuel circulating beneath the skin
Northrop X-4	25' 0"	20' 0"	app. 7,000	2 × Westinghouse J-30	1,600	Mach 0.85	Tailless model with elevons
Bell X-5	32' 9"	33' 4"	app. 10,000	Allison J-35	4,900	Mach 0.9	Variable-sweep wing
Lockheed X-7	app. 15	app. 33	app. 4,400	Marquardt ramjet	—	Mach 3.5	Pilotless test vehicle for fuel research and guided missile parts
NAA X-10	—	—	—	—	—	—	Test vehicle for aerodynamic research and electronics components
Douglas X-12	—	—	—	Rocket motor	—	Mach 5	Manned experimental aircraft
Ryan X-13	—	—	—	R.-R. "Avon" jet	—	—	Experimental VTOL type
Bell X-14	—	—	—	Jet engine	—	—	Experimental VTOL type
NAA X-15	—	—	—	Rocket motor	—	Mach 10 at app. 500,000 ft.	Pilotless test vehicle for extreme speeds and altitudes
Lockheed X-17	—	—	—	Rocket motor	—	—	Pilotless test vehicle for research on structural materials (I.C.B.M. programme)

wings. One particular task was to investigate certain stability qualities and eliminate a number of unfavourable phenomena arising with this wing shape. The X-4 also offered an opportunity of testing the behaviour of swept tailless aircraft with elevons. The latter are today used in almost all delta-wing aircraft, though they still present certain problems as regards stability and control surface effectiveness in the transonic range. The endurance at full power of the X-4 with its two Westinghouse J-30 jets was only 15 minutes, since only 240 gallons of fuel could be carried because of the weighty instrumentation fitted.

A new idea was tried out in the single-jet Bell X-5, namely a variable-sweep wing which could be adjusted during flight to adapt the wing sweep—within certain limits—to the Mach number. The wing-setting mechanism was coupled with a device which simultaneously compensated for the change in centre of gravity.—Flying the X-5, however, proved a ticklish job, because of stability deficiencies. On October 13th, 1953 the first of the two prototypes crashed, and the pilot was killed. The second prototype also reportedly crashed later.



Lockheed X-7, a test vehicle for trials with ramjets and guided missiles.

*

During recent months information has been released on a series of new experimental aircraft and test vehicles, revealing that the flight research programme financed by the U.S. Air Force and Navy is being considerably extended (cf. accompanying table). Several of the new X models are designed as unmanned, remote-controlled vehicles, since the conquest of further altitude and speed ranges makes demands that are far beyond the limits of human endurance. But even if the machine emerges as victor in this duel between test pilot and robot, it is certain that the *history of the X aircraft has been written by daring American test pilots.*

What's in the Air?

Extracts from Interavia Air Letter, *daily international news digest, in English, French and German. All rights reserved.*

AIR TRANSPORTATION

● **A new air transport agreement** has been signed between the three Scandinavian countries and the German Federal Republic. It enters into force on October 7th and replaces the old agreement which expired on September 22nd. In general terms the new agreement substantially reduces the volume of Scandinavian transit traffic through West Germany. S.A.S.'s former twelve weekly landings at Hamburg on the North American services have been cut to six, plus one weekly landing at Bremen. On its South American services S.A.S. may now land at Frankfurt only once a week, instead of twice. In addition, the number of passengers that may be picked up or set down in Germany has also been cut. No change has been made in traffic rights on the routes to Africa, the Near and Far East. — The new agreement also gives Deutsche Lufthansa the right to open new services to the three Scandinavian capitals. Further talks are planned to discuss other questions of European operations outstanding between the two airlines. The present agreement runs until March 31st, 1958.

● **British European Airways** is planning to increase passenger fares on all internal routes except one—the London-Belfast route—by 10% in December, it has been announced by A. H. Millward, the Corporation's Chief Executive. The increases, he explained, are necessitated by rising costs, mainly of wages; all B.E.A.'s domestic routes are uneconomic and have hitherto been subsidized by the international routes. The increase on the London–Belfast route will be 6% only.

● **B.E.A. and Aer Lingus** have concluded an agreement providing for closer coordination of air services between the Republic of Ireland, the United Kingdom and the Continent. B.E.A. has obtained traffic rights from next April on the London–Dublin, Birmingham–Dublin and Manchester–Dublin routes, which have been a monopoly of the Irish airline since 1946. In return Aer Lingus has been granted traffic rights to operate services from Dublin via Manchester to Brussels, Frankfurt, Düsseldorf, Amsterdam, Zurich and Rome.

The arrival of Scandinavian Airlines System's first Douglas DC-7C at Stockholm-Bromma Airport was greeted by (left to right) aircraft captain Lennart Ahnberg, Arthur Raymond (Douglas), S.A.S. President Henning Throne-Holst and Captain Ola Ness.

● **Supersonic passenger aircraft** should not be expected until after 1970, and until then the bulk of high-speed transportation will be provided by pure jet aircraft flying at subsonic speeds, predicts George F. Worley, Chief of Advanced Design at Douglas Aircraft Co.'s Santa Monica Division. The reason, he said, was the limited range and high operating cost of supersonic aircraft. Other points from the paper read to the National Turbine-Powered Air Transportation Meeting of the Institute of the Aeronautical Sciences: 1) turbojet engines provide the best motive power for transports except where field lengths are limited; 2) turboprop engines are most satisfactory where field lengths are restricted and high speeds are not important; 3) aircraft capable of extremely short take-offs and landings will probably come into use for local services during the next decade; 4) nuclear power will be adapted for use in large transport aircraft by 1970—but only for military purposes at that time; 5) long-range rockets will serve no useful transportation purposes before 1970 since their payload is severely limited by the amount of fuel required.

● **The White House** has appointed an eleven-man scientist-engineer team to study and make recommendations designed to make the best use of air space within the coming few years. The group will work under the direction of Edward Curtis, Presidential Assistant for Air Matters. Preparation of a comprehensive long-range plan to meet problems raised by rapid expansion in air travel, to be presented to the White House and possibly the 85th Congress, will start immediately. The plan is to take into account not only the use of airports but also the most efficient utilization of air space and the problems of aircraft control.

● **The U.S. Aircraft Industries Association's** Export Committee will hold a "Latin American Aviation Conference" in Miami, Florida, from November 14th to 16th, to discuss a coordinated programme of inter-American aviation activities. Officials of the Latin American military air services and airlines will be invited to meet U.S. Government aviation leaders and representatives of the American aircraft industry. In addition, U.S. airlines operating in Latin American countries will be invited. The Conference will cover the present and future needs and availability of equipment for military and naval aviation. Requirements for civil aviation products including transports, utility aircraft, helicopters, engines and major accessories also will be major subjects for discussion. Other topics include: export-import policies and problems involved in Latin American purchases of aircraft, engines and components from U.S. manufacturers; the mechanics of procurement, technical services, supply and maintenance, and methods of financing future military and commercial aviation purchases.

● **Airservice Inc.** is the name of a new company founded in Geneva, Switzerland, to undertake transport operations of all kinds, in particular by air, to buy, sell, charter or operate aircraft, ships and other means of transport on its own account or for third parties. Paid up share capital amounts to 50,000 Swiss francs, divided into 500 shares of 100 francs each. Board of Directors: Olivier de Ferron, Chairman, Geneva; Peter Buttler, Secretary, Geneva; Hans Eisenhut, Geneva; Ludcer Collins, London, and Léon Gardner, Los Angeles. Address: 5, Quai de l'Ile, Geneva.

Loading an SM-62 *Snark* guided missile on to a Douglas C-124 *Globemaster* for transport to its launching bases. Wings and tail unit are carried in the same aircraft and assembled "in the field".

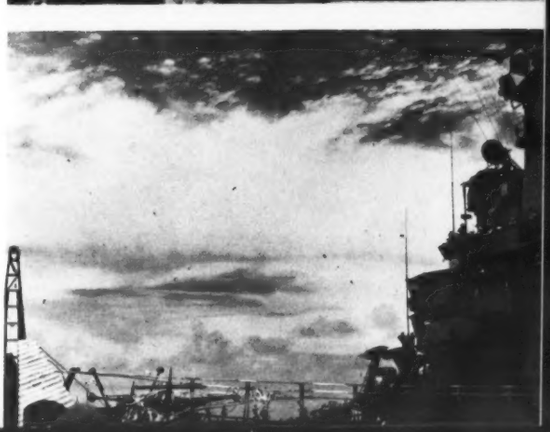
General Nathan F. Twining, Chief of Staff of the U.S. Air Force, presents Colonel Horace A. Hanes with the 1955 Mackay Trophy for the most meretorious flight of the year. Colonel Hanes set up a new world speed record in level flight (822.135 m.p.h. = 1,323.312 km/h) in an F-100C on August 20th, 1955.

Marconi's Wireless Telegraph Co. Ltd. announces the appointment of J. P. Wykes (left) as Manager, Maritime Division, and B. G. H. Rowley (right) as Assistant Commercial Manager.

Ralph A. Lamm has been appointed Director of Engineering, Pacific Division of Bendix Aviation Corporation.

Bryan Sandford Clark, manager of the European office of the Garrett Corporation of Los Angeles, recently opened in Geneva, Switzerland.

The operation of the barriers on an aircraft carrier is illustrated by this series of pictures. A Grumman F9F-5 *Panther* which has missed the arrester cables, is first braked by the Davis barrier (transverse cables) and then caught by the barricade (vertical cables) and brought to standstill on the flight deck. The pictures a were taken aboard the U.S. aircraft carrier *Lake Champlain*.



INDUSTRY

● **The first production programme** of the West German aircraft industry covers orders to a value of DM 35,000,000. The following foreign aircraft will be built under licence: 194 Italian Piaggio P.169 trainers (Prof. Blume and Focke-Wulf A.G. Working Group, Bremen); 360 French Fouga CM-170-R *Magister* jet trainers (Flugzeugunion-Süd, GmbH, Stuttgart); 117 French SNCA du Nord 2501 *Noratlas* transports (Flugzeugbau-Nord, GmbH, Hamburg). In addition 469 Dornier Do 27 communications aircraft will be built, and roughly 1,000 military aircraft from abroad are expected to be received for "de-cocooning" for the German Air Force.

● **The Fokker F.27 Friendship** twin-turboprop airliner is gaining growing popularity as an executive aircraft. In the United States the General Tire & Rubber Co.—whose interests include Aerojet-General Corporation—and Continental Can Co., as well as several metal-working firms ordered *Friendship* airliners from Fairchild Engine & Airplane Corporation several weeks ago. Another *Friendship* has been ordered by a large Italian concern for the same purpose, the Fokker company reports, and a number of petroleum companies are interested in the type.

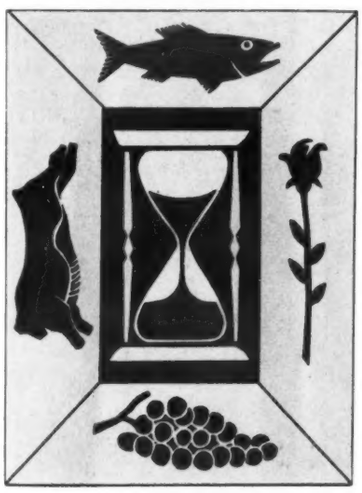
● **First official news** about the DHC-4, de Havilland Canada's new twin *Otter* being developed for the Canadian Army as a light troop transport, is that the prototype is not expected to be produced and tested for at least a year. Army specifications call for a twin-engine aircraft able to carry about 20 soldiers with full equipment and capable of landing or taking off from an area the size of a football field. Its main job would be to rush troops and equipment into forward positions, from which they could move to combat positions on foot or by helicopter. Such an aircraft would also be very important for civilian use, especially in the Canadian North.—No decision has yet been made whether the pilots will be Army or Air Force personnel. It is, however, assumed that the aircraft would be operated under Army orders.

● **The Convair Division of General Dynamics Corporation** has established a Market and Route Analysis Department to provide a more effective tool to support the sales programme for the new Model 880 jet airliner. The Department, which is headed by R.K. Waldo, an Assistant Manager of Commercial Sales, is making exhaustive studies of how Convair 880 transports will fit into airlines' routes and markets. Airlines will be provided with detailed operational information on specific routes, including block speeds, airport facilities and runway lengths, fuel requirements and gross take-off and landing weights, operating costs and passenger load potentials of the Model 880. A total of 40 Convair 880s has been ordered for Trans World Airlines, Inc., and Delta Air Lines Inc.

● **The U.S. has produced more jet engines** and its jet-powered aircraft have accumulated more flying hours than has any other nation in the world, according to "Planes", official publication of the Aircraft Industries Association. More than 88,000 jet and turboprop engines have been delivered to the Air Force and Navy since the first one was produced in 1942 and these engines have flown a minimum of 23,700,000 hours. Hundreds of thousands of hours have also been recorded in ground tests. In 1954, the magazine points out, 67% of all aircraft power plants accepted by the Air Force were turbojets. In 1955, the figure was 77%, averaging out at 8,800 lbs. of thrust. The Air Force expects to add 9,000 jet aircraft by July 1957 and has scheduled 4,700,000 jet hours during the current fiscal year. Estimates place the cost of developing a new turbojet or turboprop engine at a minimum of $ 50,000,000, not counting the expense involved in tooling for production.

● **Cessna Aircraft Co.** plans to spend more than $ 10,000,000 in the next four years on the expansion of its production facilities. Dwane L. Wallace, Cessna President, said that work on the programme would start immediately. The expansion, he explained, was mainly necessitated by the Air Force's $ 26,000,000 order for T-37A jet trainers. "However," he added, "we would not be entering into this expansion programme if the future for the commercial aircraft business didn't look so bright."

This adhesive label, one of three designed by the International Air Transport Association in a move to standardize freight markings, will be used from October 1st for perishable goods in international air transport. The other labels mean "fragile" and "top".



AIRCRAFT AND EQUIPMENT

● Kaman Aircraft Corporation, of Bloomfield, Conn., has developed a *device to enable the pilot of a helicopter to keep his blades in track* (i. e., with their tips rotating in the same plane) during flight. Hitherto "tracking" helicopter blades has been a troublesome task which has had to be performed by a mechanic on the ground. Now it can be done within seconds by the pilot, who merely has to operate a small crank in the cockpit.

● *Lear L-17 automatic pilots* have been ordered by Air France for its SE.210 *Caravelle* jet transports. The new system uses transistors to replace all vacuum tubes and, in addition to the guidance control provided by conventional autopilots, incorporates automatic stability augmentation in all three

The "City of Renton", first production model of the Boeing KC-135 jet tanker, during its maiden flight on August 31st, 1956. In the background the prototype of the Boeing 707 jet commercial transport. – Output of KC-135 tankers for Strategic Air Command is to be increased to twenty per month.

Two-seat F-100F version of the North American *Super Sabre* fighter, which can be used for training purposes or as a fighter-bomber.

axes of motion, automatic heading selection and control, automatic approach control for instrument landings.

● The *Edgar Percival E.P.9* agricultural aircraft is now going into full production at the Edgar Percival Aircraft Ltd. plant at Stapleford Aerodrome, Essex. At the moment firm orders for seven aircraft have been received; eleven are already in production, and a total output of 150 is planned for the coming year. Price of the fully-equipped E.P.9 (for agricultural use) is roughly £ 9,600, and delivery can be made in about eight weeks.—The E.P.9 is also suitable for other duties than agricultural work; passenger or cargo transport (accommodation for six persons plus baggage), communications services, aerial survey, ambulance duties (two stretcher cases, one seated passenger plus pilot and attendant), etc. A military version of the ambulance layout is now under consideration by the British Army, the R.A.F. and the R.A.A.F.—Power plant is a 270 h.p. Lycoming GO-480-B with Hartzell HC-82X20-1B two-blade propeller.

● Three *Fairchild M-185* four-jet touring and executive aircraft for eight passengers and crew of two have been ordered by Continental Can Co. This aircraft is powered by Fairchild J-83 jets of 2,000 lbs. thrust each, which are mounted two-by-two on two pylons underneath the high-set wing.—Design cruising speed is roughly 550 m.p.h., cruising altitude approx. 45,000 ft., and range more than 1,500 miles.—The prototype should be ready for flight testing by the end of 1957 or early 1958, and first deliveries should begin in 1960.

● Nine *Douglas DC-8* commercial jet transports are to be used for the C.A.A. type tests; three of them will be fitted with Pratt & Whitney J-57, four with P & W J-75 and two with Rolls-Royce *Conway* engines.

● Details of the *Pasotti F.9 Sparviero* four-seat touring aircraft: low-wing monoplane of wooden construction, in part fabric-covered; retractable nose-wheel undercarriage; hydraulic operation of undercarriage retraction mechanism and landing flaps; equipped for instrument flying.—The F.9 prototype is fitted with a 240 h.p. Hirth engine and two-blade v.p. propeller; the production version is to have a 260 h.p. Lycoming engine.—Span 32.8 ft., length 27.2 ft., wing area 158.2 sq.ft., aspect ratio 6.8, weight equipped 2,094 lbs., gross weight 3,307 lbs., max. speed 200 m.p.h., ceiling 18,000 ft., range approx. 810 miles (performance figures are approximate for the 240 h.p. engine).

POWER PLANT

● A *Pratt & Whitney T-57* turboprop engine recently began flight testing, fitted in the nose of a Douglas C-124 transport.

● The following data have been released for the 180 h.p. *Lycoming 0-360* engine: take-off power 180 h.p. at 2,700 r.p.m., length 29.6 ins., width 33.4 ins., height 24.7 ins., weight 282 lbs., 91/96 octane fuel. The engine is to be used, for example, in the Beech 95 *Badger*.

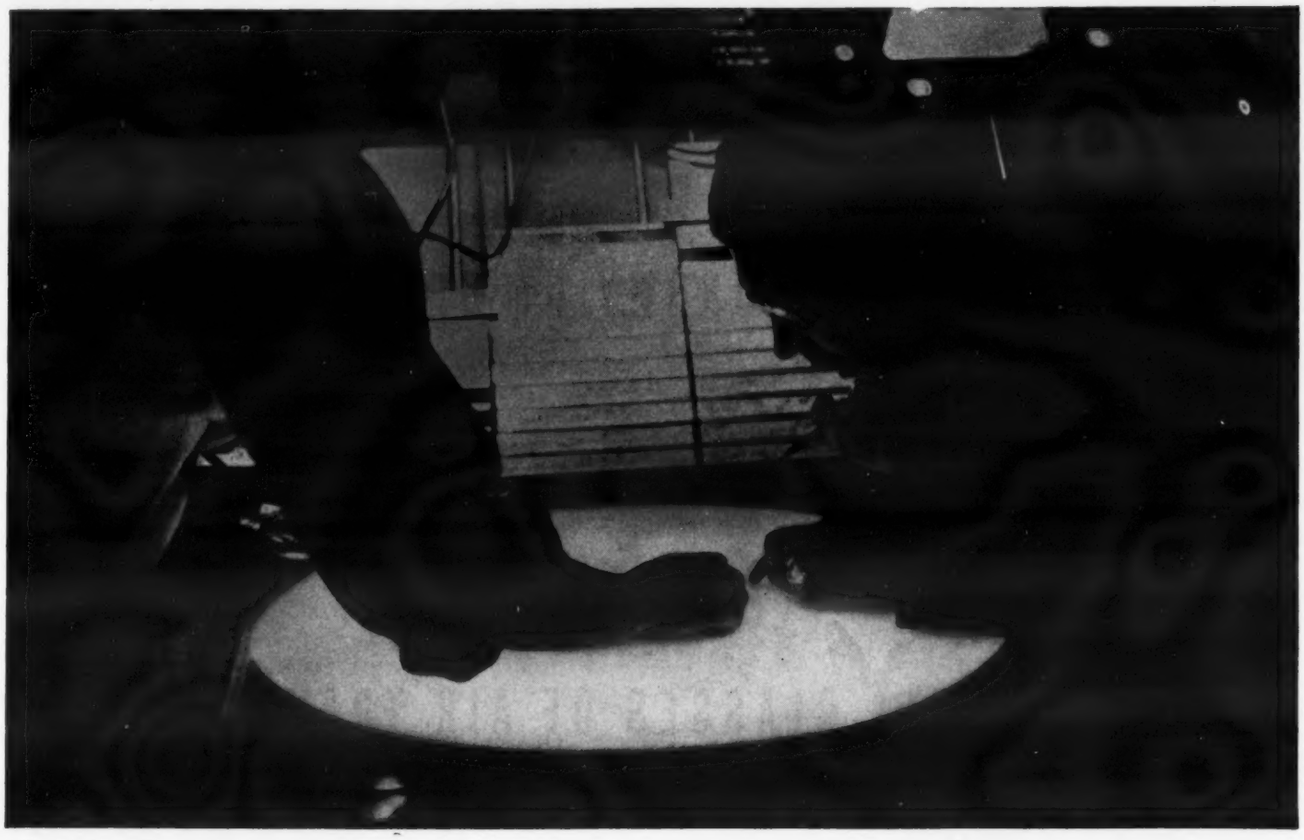
● Price of the *General Electric CJ-805* turbojet, which is planned for installation, for example, in the Convair 880 *Golden Arrow* commercial transport, is given as $ 125,000. If silencer and thrust reversal device are fitted—as is projected for the Convair 880—an extra $ 30,000 to $ 40,000 must be added.

● *Japan Jet Engine Co.* is next year to build the prototype of another jet engine, to be known under the designation J-5. This will be in addition to the J-3. The J-5 is designed for use in a number of projected aircraft types of Japanese design. Thrust approx. 7,720 lbs.

● Kawasaki Aircraft's KAE-240 air-cooled flat-six engine (260 h.p. take-off and 240 h.p. rated power has been granted an official type certificate.

Chance Vought F8U-1 *Crusader* Navy fighter, which is armed with guided missiles and 20-mm cannon.

What Do You Look For In Radar?



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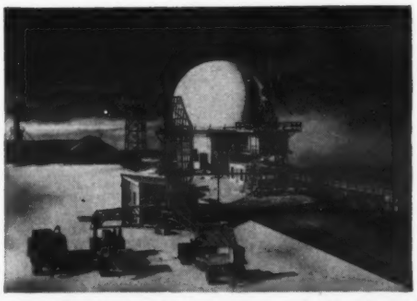

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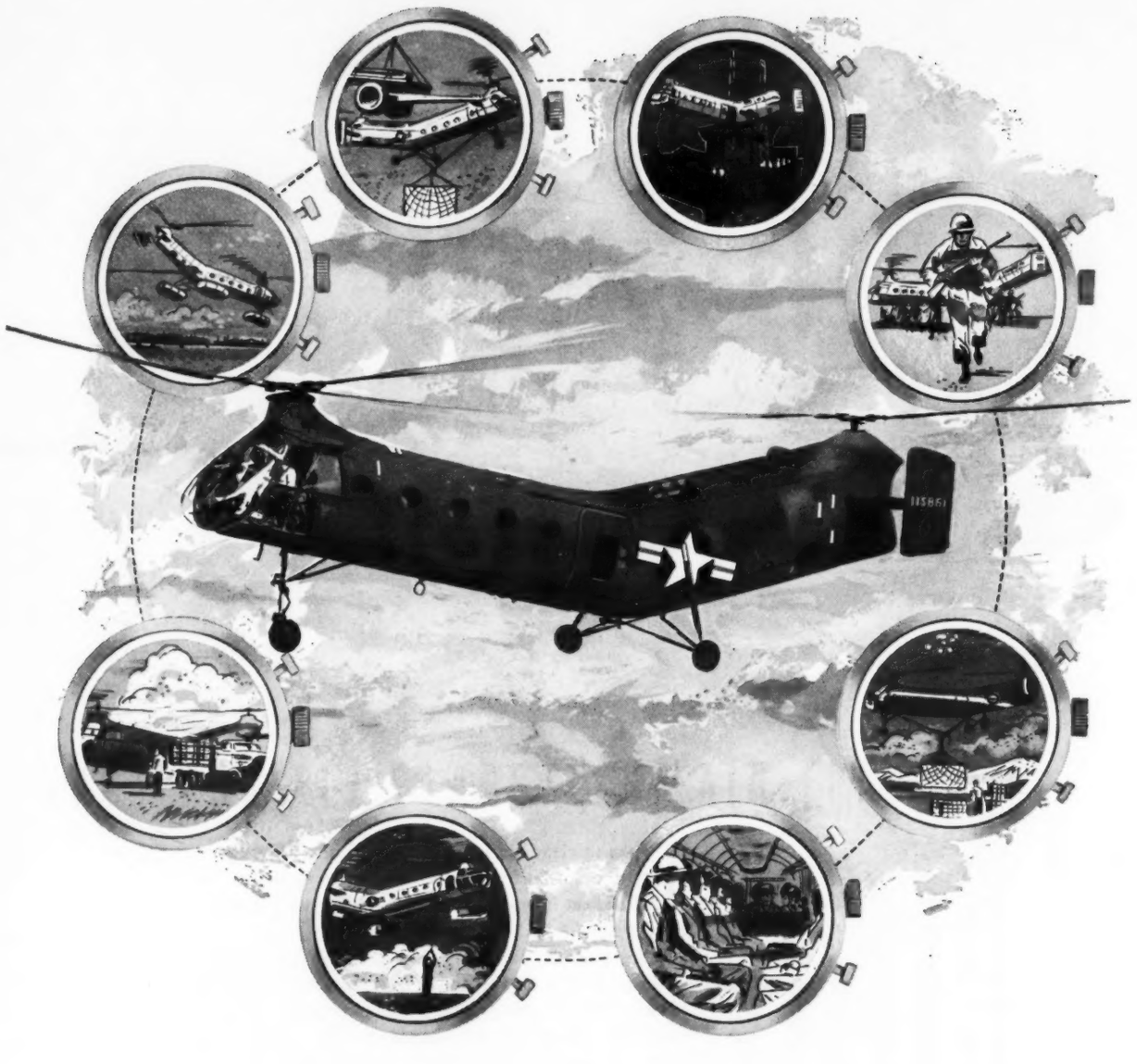

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The TACAN System and the Results of the Alaska Tests

Of the three major navigation problems in modern aviation—long-distance navigation, medium distance navigation, instrument landing—the second can be regarded as having been solved in principle. The TACAN system (Tactical Air Navigation), which combines the latest methods of radar distance measuring with use of polar coordinates, seems to be emerging as final solution for medium-distance navigation.

Though the main characteristics of TACAN are today widely known,[1] it may be useful to repeat them below in brief :

1 – *An airborne transmitter (interrogator) provides distance measurement (DME)* with the aid of pulses answered by the ground station. Distance is measured from the travel time of the signal back and forth. It is also possible to send other information in the same way from the aircraft to the ground station, or vice versa. Hence many air traffic control problems could be solved by developing auxiliary equipment to TACAN.

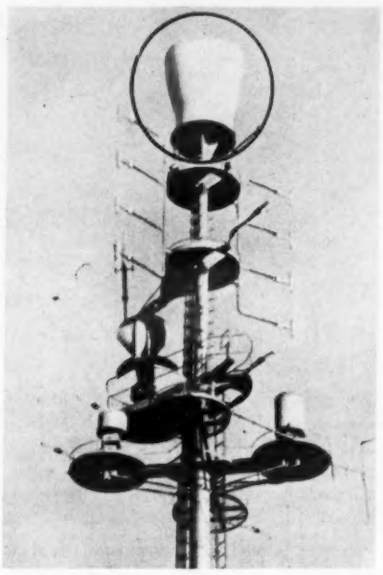
2 – *Distance measuring and bearing indication (of the aircraft position in relation to the ground station) are provided on the same frequency.* In addition to measuring the travel time of the airborne signals and the ground station's replies, the airborne equipment also takes bearings on the ground station, using the directional amplitude modulation produced by the latter's antenna which rotates at 900 r.p.m.

3 – *The accuracy of the bearing indication is extremely high.* As it is basically a *radar procedure*, in which the beam measures only 1 to 2 degrees, accuracy is naturally higher than that of an omnidirectional beacon with rotating cardioid (e.g., VOR), which has an accuracy in the VHF range of only 4 to 5 degrees. This value can hardly be improved even under the most favourable conditions, and can rise to 10 degrees under bad conditions. This high margin of error is attributed to the fact that the relatively wide antenna cardioid encounters numerous ground obstructions and is distorted by their reflections. A thin radar beam, on the other hand, is largely unaffected by ground reflections.

[1] Cf. *Interavia* No. 10, 1955 (" The TACAN UHF Navigation System "), also the March 1956 issue of the ITT's journal " Electrical Communication " (article by R. I. Colin and S. H. Dodington), and the press conferences held in Paris, Berne, Rome and Pforzheim during recent weeks by H. Busignies, President of Federal Telecommunications Laboratories, a division of International Telephone and Telegraph Corporation.

*

Production of the ground and airborne equipment for the finalized TACAN system began in 1954. All frequencies used (2×126 channels) are quartz-stabilized and lie within a relatively narrow band (962-1,213 mc/s). To ensure high bearing accuracy the antenna pattern has nine ripples superimposed on the basic cardioid. In addition air-to-ground and ground-to-air communications are provided for air traffic control purposes, and the installation of fixed auxiliary equipment for instrument landings, similar to the ILS system, is planned. Indeed, an experimental TACAN-ILS system has already been built, with the normal TACAN ground station being equipped with a special antenna for instrument landings, while the airborne equipment in the test aircraft remains virtually unchanged, except for the installation of an additional cross pointer. The system combines all the advantages of the present standard ILS system with those of a higher frequency (around 1,000 mc/s) and also offers continuous indication of distance from the beginning of the runway.

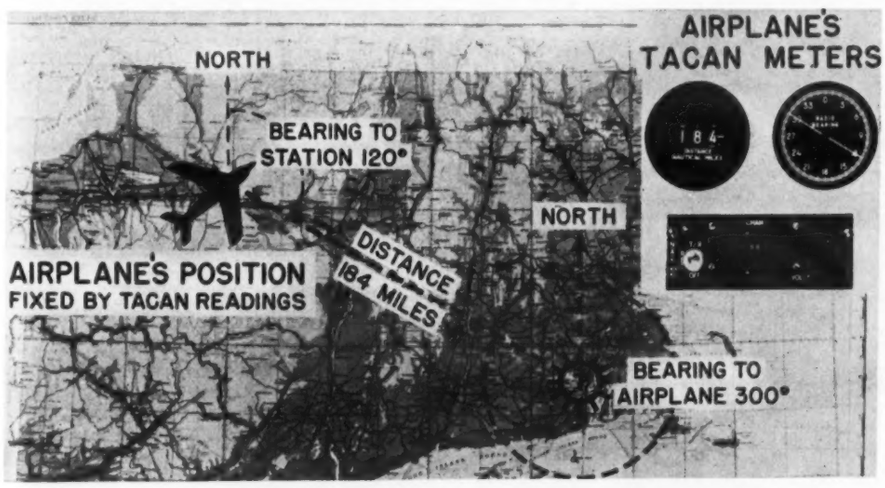


TACAN antenna (in circle) on the mainmast of a U.S. aircraft carrier.

A particularly important point is that the TACAN specification requires each ground station to be capable of supplying bearing and distance information to 100 aircraft simultaneously. As a total of 126 double channels (for 126 TACAN stations in the same major region) is provided, the overall capacity of the system is *12,600 aircraft.*

Finally it should be stressed that TACAN is fully reliable over all distances (ground station to aircraft) up to 200 nautical miles. Within this range, the pilot obtains a clear picture of his position from the bearing and distance readings. He can also home on to a selected ground station and be instructed to carry out any manœuvres, such as circuits in order to take his proper place in the " landing queue ". Last but not least, when TACAN navigation is used, aircraft need not be crowded over certain points or along fixed airways, but can be distributed over the airspace in the most suitable manner.

The radio bearing (from instrument top right) and distance in nautical miles (left) give the pilot at all times a clear picture of his position. Below the two instruments is the control unit, set to chain 50.



TACAN and VOR/DME

To what extent is the TACAN system in use in the United States? The U.S. Air Force and Navy have already introduced it on a wide scale, after several years of thorough testing have shown the equipment to have reached the operational and production stage.

In addition, development of airborne equipment for commercial aircraft is nearing completion. Here, however, it should be remarked that the situation in the civil domain is not quite so simple as in the military. Undoubtedly the existence of an adequate number of TACAN ground stations in the busy regions of the United States would be welcomed by the airlines, who would then purchase the necessary airborne equipment. But it will take some time to erect the civil TACAN stations, so that in the meantime the airlines will have to make do with existing aids, chiefly VOR beacons. The existence of TACAN and VOR side by side

The AN/ARN-21 airborne TACAN set comprises the following components (left to right) : RT-220 transmitter-receiver with MT-928 rack ; CV-279 phase comparator ; ID-307 bearing indicator (azimuth and course) ; ID-310 distance indicator ; C-866 control unit.

has given rise to endless arguments, with discussion centering around the introduction of TACAN as part of a common civil and military system. Just recently, however, the Air Coordinating Committee has finally pronounced in favour of TACAN.

Nevertheless it is obvious that the rival VOR system, for which more than 400 ground stations have already been built in the United States alone—while large numbers of commercial and private aircraft have been equipped with VOR navigation receivers—will remain in service for many years to come. The barrier to the " co-existence " of VOR-DME (i.e., VOR plus 1,000 mc/s distance measuring equipment) on the one hand and the TACAN system on the other is the well-known fact that both systems contain a distance measuring portion in the same frequency band (approx. 1,000 mc/s). But whereas the DME portion of the civil system works on the multiplex process on ten channels with ten codings each, the DME portion of the military system uses 126 individual double channels.

The U.S. armed services have now evolved a method of converting the several hundred civil DME stations already in operation to the military DME system, so that the high investment cost of these installations can be at least partially amortized. It was ultimately the practical proof that the civil DME equipment could be converted which decided the A.C.C. in favour of TACAN. In future, therefore, civil users of the modified VOR/DME system could also utilize the TACAN beacons for distance measuring, while military pilots would have an additional navigation aid in the civil DME transponders. Both systems could work smoothly side by side . . . until the day when the more accurate TACAN stations were available in sufficient numbers, and the VOR stations could close down.

*

The following is the text of the (first) circular in which the A.C.C. laid down the United States' airway plan for the coming years :

" AIR COORDINATING COMMITTEE *ACC 56-8*
WASHINGTON 25, D.C.
June 21st, 1956

" The Air Coordinating Committee in its meeting on Wednesday, June 20, 1956, instructed its Air Traffic Control and Navigation Panel (NAV) to proceed immediately with the development of a plan for the instrumentation of the Federal Airways with navigational aids to supplement the present omni-range VOR and to provide clear channel (TACAN compatible) distance measuring equipment and the necessary airborne counterparts thereof in time to meet the need of the new high performance civil aircraft.

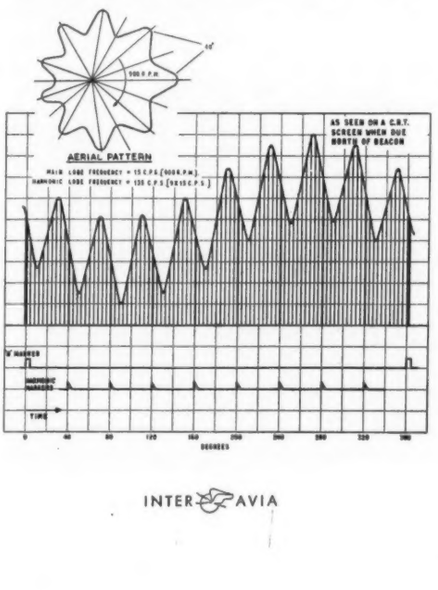
" It further instructed the NAV panel to prepare a factual report on the possibilities of an alternate Rho-Theta System which would combine the best features of equipments now in being plus any necessary modifications thereof. Both reports are to be completed as soon as possible and, in any event, not later than August 20, 1956.

" The member states of I.C.A.O. will be kept fully advised about technical developments of TACAN. The U.S. will consult with them through I.C.A.O. as to the course of action permitting orderly transition to any possible new standards in accordance with its international cooperation policy.

" The Air Traffic Control and Navigation Panel is composed of the responsible navigation and traffic control officials and experts of the Federal agencies and industry. It is under the chairmanship of the C.A.A. Administrator, Mr. Charles J. Lowen, and will operate on a full-time priority basis until its report is completed and transmitted to the Air Coordinating Committee.

" The Air Coordinating Committee is comprised of top officials of the major Federal agencies, and was established by the President for the purpose of coordinating important aviation policies and programs. Its members are : Louis S. Rothschild, Chairman, Under Secretary of Commerce for Transportation ; Chan Gurney, Vice Chairman, Member, Civil Aeronautics Board ; Herbert V. Prochnow, Deputy Under Secretary of State for Economic Affairs ; David W. Kendall, Assistant Secretary of Treasury ; E. George Siedle, Assistant Postmaster General ; George H. Roderick, Assistant Secretary of the Army ; James H. Smith, Jr., Assistant Secretary of Navy for Air ; Dudley C. Sharp, Assistant Secretary of the Air Force ; Robert E. Lee, Commissioner, Federal Communications Commission ; Percy Rappaport, Assistant Director, Budget Bureau ; Alvin B. Barber, Consultant for Transportation, Office of Defense Mobilization."

Antenna diagram of a TACAN ground beacon and amplitude modulation envelope for the azimuth signals which would appear on a cathode ray tube due north of the beacon. The receiving times for the main signal and the eight 40° auxiliary signals are also shown.



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This was followed on August 20th, 1956 by another A.C.C. circular reading :

" AIR COORDINATING COMMITTEE *ACC 56-7*
WASHINGTON 25, D.C.
August 20, 1956

" Louis S. Rothschild, Chairman of the Air Coordinating Committee (ACC), announced that the ACC in its meeting today recommended a national program for integrating the very high and ultra high frequency electronic civil and military air navigation systems into the common system in order to provide the most comprehensive and modern distance measuring and directional navigation service throughout the United States. This integrated navigation system will be known as " VORTAC ".

" The ACC took this major policy action primarily because of extensive military requirements for high performance aircraft operations and the planned introduction of civil jet transport flights in the United States in 1959, both of which require a compatible distance measuring system in the interest of national defense and a common system of operation.

" The needs of the thousands of private and business airplane owners will be accommodated by the U.S. VORTAC program. This includes continued and expanded implementation of the very high frequency omnirange (VOR) azimuth navigation system with its associated voice and ILS localizer features into the long term future. Integrated with this will be a mutually compatible ultra high frequency system which will provide distance information for both military operations and civil aircraft flights, and azimuth information for military use.

" Under the VORTAC plan, the military tactical air navigation system (TACAN) is integrated into the U.S. common system to meet the national defense requirements of the country and provide tactical azimuth information to all users.

" The present distance measuring system can be retained until 1960 except as a frequency or other conflict makes this impractical in order to reduce the effect of the change to the one to three hundred aircraft owners now reported to be using airborne distance sets of this type.

" Recognizing the urgency of accelerating the Federal Airways program, as recently recommended by both the President and the Congress, the ACC took prompt action to complete the proposed air navigation implementation plan following two months of full time exhaustive study by experts of government and industry who make up the ACC Air Traffic Control and Navigation Panel. This Panel will further review the proposed plan for the purpose of adding to it such other requirements of general aviation as may be indicated . . .

" The ACC conclusions which constitute the proposed course of action are as follows :

" 1 – The Omni Range VOR Azimuth Navigation System is required by all categories of aircraft operators, and will continue to be expanded as planned both at present and in the long-term future.

" 2 – TACAN should be integrated into the Common System to meet military requirements.

" 3 – The military services will continue their implementation of TACAN in order to meet the national defense requirements of the country. These facilities will be integrated operationally into the domestic Federal Airways and the Air Traffic Control System.

" 4 – The Clear-Channel Distance Measuring Equipment will be integrated into the navigation system in order to provide the civil jet transport, military jets, and other civil and military aircraft with distance measuring and improved air traffic control service by July 1, 1959, for high altitude enroute and for terminal operations.

" 5 – Specifications and prototype equipment should be developed for a TACAN compatible ground DME intended for use at certain VOR and ILS sites, either domestic or international, where required . . ."

(There follow another six points, including an offer of financial aid for civil operators to exchange their old DME equipment for new VORTAC/DME sets. Finally, the members of the Air Coordinating Committee are again listed, the only change being that Garrison H. Norton has replaced James H. Smith, Jr. as Assistant Secretary of Navy for Air.)

Tests and results

Once the capacity and operating reliability of the TACAN system had been proved, the U.S. Navy and Air Force decided to increase the output of TACAN equipment. The theoretical capacity of 100 aircraft per ground station was checked in practice, and it was found that even when up to 125 aircraft were operating simultaneously no difficulties were experienced on the DME side. As regards bearing indications capacity is of no importance, but there are limits to the distance measuring function. It is noteworthy, however, that these limits were not reached even when 125 aircraft interrogated the same ground station simultaneously.

The life of the equipment now in production has been increased to such an extent that it has proved impractical to check it in flight. It would be too costly to keep a jet aircraft in the air upwards of 200 hours merely to test wear and tear on the TACAN equipment.

In Alaska, TACAN airborne equipment was initially kept in continuous operation for 16 hours without change of tubes or any kind of repair being necessary. And more than two years ago the Navy's airborne equipment was operating for 40 hours without trouble. Meanwhile further improvements have been made and operating life still further increased. In recent endurance trials, however, the system of tests in aircraft has been abandoned, as it was found more practical to submit groups of 50 sets to the varying stresses of temperature changes, vibrations, flow changes, etc. in a special test chamber, where flight conditions are realistically simulated.

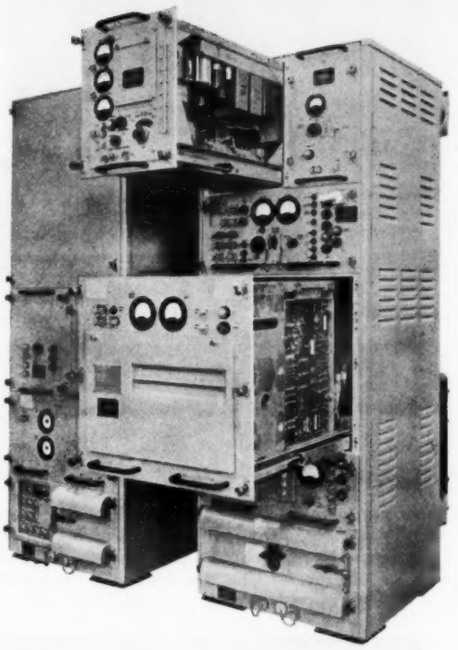
The groups of 50 sets functioned completely satisfactorily in the test chambers during 230 hours of uninterrupted operation. This is about four times as long as the usual maximum operating time (between overhauls) in practical air transport for electronic equipment with a comparable number of tubes.

As for the ground stations, they have been operated for 800 hours without interruption of any kind. The transmitter's klystrons have been found to be particularly reliable and gave absolutely no trouble even in Alaska's hard Arctic winter.

The main object of the tests in Alaska was to obtain reliable *statistical* information on the accuracy and reliability of TACAN equipment under extreme climatic conditions and far from industrial maintenance centres. For this purpose, no fewer than seventeen TACAN ground stations were set up in the autumn of 1954 and were used by a large number of aircraft with TACAN airborne equipment.

A selected group of specialists was made responsible for erecting the stations and performing normal maintenance. These men also collected extensive information for the statistical evaluation of the test results.

Prototype of an airborne TACAN receiver for private aircraft.



AN/URN-3 transmitter-receiver of a TACAN ground station, with sliding cabinets.

The layman can scarcely imagine the multitude of difficulties encountered in first setting up the ground stations, particularly during an Arctic winter. The greatest trouble was experienced not with the actual TACAN apparatus, but with the accessories.

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Major results of these tests were as follows :

1 – Reliability of the TACAN airborne equipment was improved step by step, so that operating life increased from 16 to 85 hours.

2 – Operating life of ground stations improved from 100 to an average of 400 hours and to as much as 1,600 hours in isolated cases. Certain klystrons have already exceeded the " Biblical age " of 5,000 operating hours.

3 – In some cases the ground stations were set up on sites where all other navigation aids would have failed. Even in the most unfavourable terrain and with the TACAN antenna only 16 ft. above ground, there was no reduction in the accuracy of distance measuring, and accuracy of bearing information was only slightly affected. In particular, accuracy was unaffected by ground formation in all cases where there was a direct line-of-sight connection from the aircraft to the ground station.

If an aircraft navigating on TACAN enters the " wave shadow " of a mountain range, the signal simply vanishes, so that the pilot at least receives no false information. It should, however, be possible, after detailed study of all the factors involved, to distribute TACAN stations over a given territory in such a way that regular cover of the airspace by UHF signals is ensured.

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In brief, the TACAN tests in the icy wastes of Alaska were a complete success. They demonstrated the system's high degree of accuracy, efficiency and reliability.

A Glance at the Farnborough Exhibition Tent

Electronics and other equipment

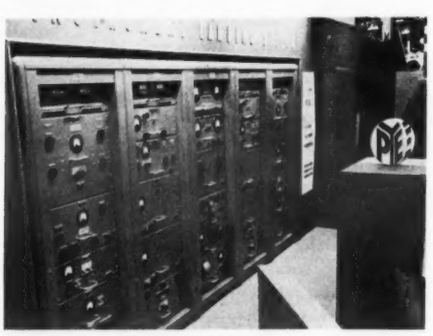
As forecast in the last issue, no radically new aircraft types appeared at Farnborough this year. True, new versions of known types and newly-adapted "flying test beds" were shown, but the flying demonstrations at the 17th S.B.A.C. Display (September 3rd to 9th, 1956)—a report on which will be published in the November issue—scarcely differed from last year's.

Once again the main emphasis of the Show was on turbine engines and rocket motors—to which a special report will be devoted—and on electronic equipment and other aviation accessories. The following pictures and brief notes form a first selection from the multiplicity of exhibits.

● **Marconi's Wireless Telegraph Company,** Chelmsford, Essex: A new exhibit at Farnborough was the **radio link** which transmitted radar and television images from London Airport to a cabin on the Marconi stand, 20 miles distant. The system works in the 4,000 mc/s band. A diagram of the system and a picture of the receiver truck are shown on page 786 of this issue. Special features are the small bandwidth of 8 mc/s (for four transmission channels) and a transmitter output power of only 2 to 3 watts. Both transmitter and receiver are equipped with the new Travelling Wave Tubes.

● **Standard Telephones & Cables Ltd.,** London, and **Creed & Company,** Croydon: In experimental operation on B.O.A.C.'s Atlantic services since March of this year, the Creed **radio teleprinter** (Model 75), controlled by a Standard special receiver, prints meteorological and navigation information in standard page form at the rate of 100 words a minute. Weight of complete airborne installation is slightly over 50 lbs.; range up to 1,500 nautical miles; four frequencies between 90 and 140 kc/s.

● **A.C. Cossor Limited,** London: Secondary radar stations are now available in a motorized version and have been ordered, for example, by the United States Air Navigation Development Board. Cossor also exhibited miniaturized versions of the related airborne identification equipment, as well as the new Type 21 mobile primary radar for 10-cm waves (S band) with Moving Target Indication.



● **Pye Limited, Telecommunications Division, Cambridge:** Crystal-controlled dual VHF transmitter for the **localizer** of Pye's new instrument landing system at Geneva-Cointrin Airport, which is to go into operation this autumn (cf. No. 10, 1955, p. 791).—Other exhibits included the **Gliderphone**—a light-weight communications set for gliders—and the **Transhailer,** an electronic megaphone (with battery and transistors) for use over distances of up to 400 yards.

● **Elliott Brothers (London) Ltd.** produces, under Bendix licence, the X-band (9,375mc/s ± 30 mc/s) **RDR-1 airborne radar,** whose antenna reflector group (rotating at 15 r.p.m.) and PPI scope are shown here. The antenna mounting is stabilized by the vertical gyro of the aircraft's autopilot, but can be tilted 15° up or down from the horizontal. Other features: Iso-Echo Contour display; pulse width 2 microseconds; pulse frequency 380 to 420 c/s; total weight 118.5 lbs.; range 150 nautical miles.

● **P. Frankenstein & Sons (Manchester) Ltd.,** has developed, in conjunction with the Institute of Aviation Medicine, a full pressure suit inflated by oxygen (pressure differential at least 4 p.s.i.) with breathing apparatus for pure oxygen. The high-altitude suit has no metal fittings or seals, which increases the pilot's comfort and reduces the risk of injury during ejection of his seat.

● **Martin-Baker Aircraft Company Limited,** Higher Denham, Middlesex: Mark 4 fully automatic light-weight ejection seat with two drogues (in tandem) for stabilizing the seat and opening the pilot's parachute. The telescopic ejection gun also serves as guide rail; thigh guards and footrests have been replaced by a leg restraining gear. Weight installed, including ejection gun, 80 lbs.

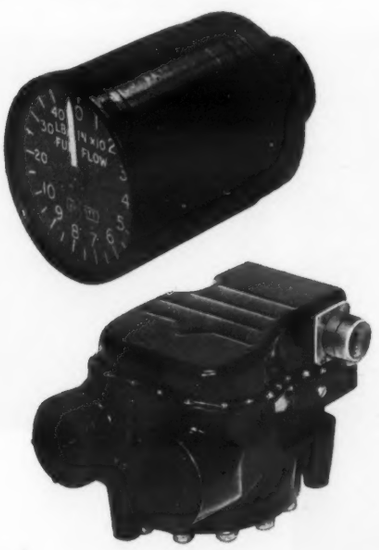
● **Rotol Ltd.,** Gloucester, exhibited, in addition to the ram air turbines to drive accessories described in Interavia No. 1, 1956 (p. 59), a number of accessories for the 4,000 h.p. Rolls-Royce " Tyne " turboprop and the four-blade v.p. propeller, illustrated here, for the more than 2,000 e.h.p. R.-R. " Dart RDa.8 " turboprop.

● **W. Vinten Ltd.,** London, makes a 16-mm combat recording camera for jet fighters designed to a Ministry of Supply specification to meet the optical conditions prevailing at high altitudes and high speeds. It is operated by a 25 to 29 volt D.C. motor and can be supplied with either a 1½-in. f 2 lens or a 3-in. f 3.5 lens. The following exposures and film speeds can be set on the ground: 1/200th of a second (8 pictures per second); 1/400th sec (16 pictures) or 1/800th sec (32 pictures). Weight of the complete camera is 4.25 lbs., overall length (with 3-in. lens) 8.85 ins., height 3.28 ins.

● **Ferranti Ltd.,** Edinburgh, showed a gyro gunsight for light fighters which can be used for firing guns or rockets air-to-air or air-to-ground. With an additional control unit (not shown here) radar-ranging input can be incorporated. The standard version illustrated—consisting of sighting head and one switch unit—weighs only 7 lbs.

● **Flight Refuelling Ltd.,** Blandford, Dorset: In order to be able to use the conventional underwing pressure fuelling equipment for refuelling aircraft with overwing filler caps, the company has developed a simple extension pipe which is introduced into the filler from above. No modifications are required to the actual coupling; rate of flow is regulated according to visual on/off indications, as in the standard version.

● **Elliott Brothers (London) Limited :** Fuel flowmeter for continuous indication of consumption per minute and total consumption. The fuel flow transmitter (bottom) with variable area orifice operates the indicator (top) and a counter for total consumption (not shown here), via an amplifier-converter. The flow indicator illustrated is designed for a flow of up to 400 lbs./min; other systems are available for flows of up to 3,000 lbs./min.

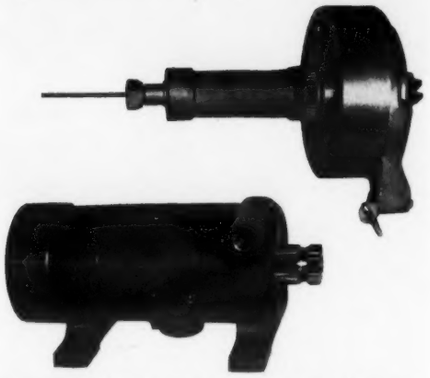


● **Smiths Aircraft Instruments Limited,** London, has developed for the Ministry of Supply a motorized altimeter which operates from 0 to 100,000 ft. A counter showing altitude to the nearest 50 ft. is combined with a pointer making one revolution of the dial for each 1,000 ft. Movements of the pressure sensitive capsule alter the position of an inductive pick-off, whose signals—after amplification in a separate anti-vibration amplifier—control the indicator motor and thus operate the indicator mechanism. In this way much greater sensitivity can be obtained with almost negligible system lag.

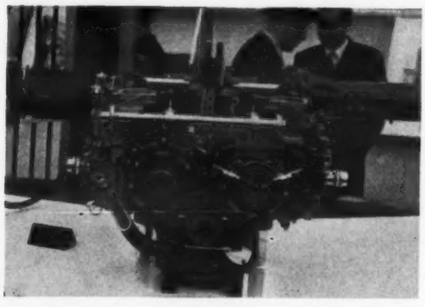
Farnborough

● **D. Napier & Son Ltd.,** London: This fin leading edge of the Bristol " Britannia " with Spraymat de-icer shows that Napier's system of surface heating can also be applied to large-area aircraft parts. The Spraymat installation on the " Britannia " tail unit covers an area of 140 sq.ft., and total power requirement is 20.4 kW.—The metal elements are embedded in special insulation layers suitable for application to Redux bonded structures.

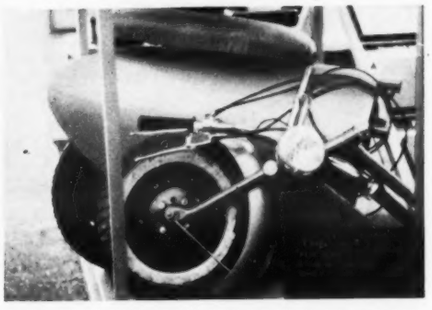
● **Goodyear Tyre & Rubber Company (Great Britain) Ltd.,** Wolverhampton, Staffs., showed its new Tri-Metallic disc brake which makes use of recent metallurgical discoveries: the moving and fixed discs are of different steels; the rotating discs are faced with an iron sintered coating which is incompatible with the steel of the fixed discs, so that there is no possibility of fusion between the two. The discs are only about 3/16 inch thick, so that a larger number of discs can be accommodated in the same size brake, giving a greater friction area and torque capacity.



● **Girling Limited,** Birmingham: Control dampers for high-speed aircraft with power-boosted controls. Both types shown, an aileron control damper (top) and the rudder control damper, are small enough to be fitted in the immediate neighbourhood of the control surface and therefore need no complicated connecting rods. Thermostats limit the effects of viscosity change through a temperature range from —60° to +80°C.



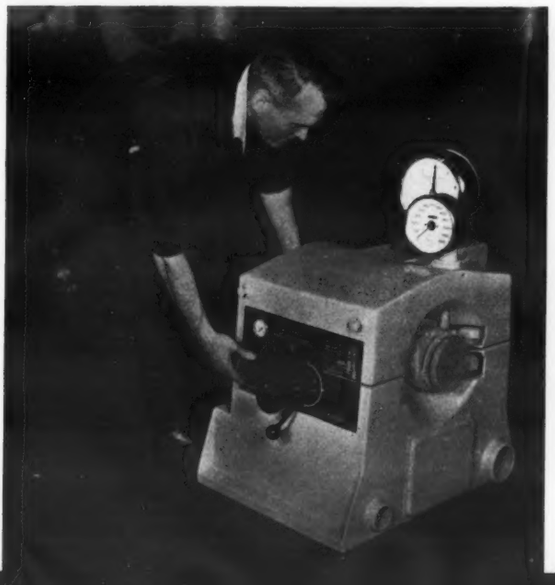
● **Boulton Paul Aircraft Ltd.,** Wolverhampton: Power boosting system for the aileron controls of a heavy bomber. Two hydraulic generators in parallel operate a hydraulic ram. If one generator fails, the other gives full load at half rate surface movement; if the complete power system fails the control surface is automatically put into direct connection with the pilot for manual operation.



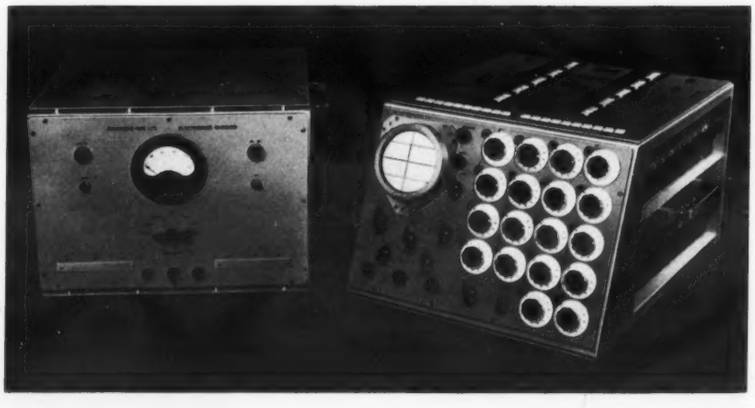
● **Airscooters Ltd.,** London, exhibited this collapsible motor scooter, which weighs only 60 lbs. It can be dismantled as shown here (and reassembled) within a minute, and can be stowed in a very small space (e.g., in the cabin of a touring aircraft), thus forming a valuable auxiliary transport vehicle for private pilots, yacht owners, etc.; 50 ccm engine; speed approx. 35 m.p.h.

● **Short Brothers & Harland Ltd.,** Belfast, has developed, in conjunction with B.O.A.C., a new folding light-weight passenger seat (Type 200) for tourist-class operation. With its light metal framework, the seat combines low weight (43 lbs. for double unit, 60 lbs. for triple unit) with comfortable shape. In its present version it can take accelerations of up to 9 g.

● **Heenan & Froude Ltd.,** Worcester, has developed a new dynamometer (Froude Type G) for testing light aircraft engines of up to 350 h.p. The machine works equally well in either direction of rotation. By turning it end to end and reversing the direction of rotation it virtually does the work of two dynamometers with different power absorptions.



● **Saunders-Roe Ltd.,** East Cowes, Isle of Wight: The Electronics Division, the Group's youngest division, has a very varied production programme, including the Miniputer analogue computer. The latter solves linear differential equations in which time occurs as an independent variable, and can thus handle almost all linear vibration problems. Both real time single sweep solutions and repetitive operation are provided. — Left, the power unit; right, the computer unit with ten operational amplifiers, eighteen potentiometer dials and a cathode ray tube for double beam.



AIRFIELD FUELLING TRUCKS

Modern aircraft design, improved power plants and new navigation systems have greatly increased the cruising speeds of aircraft. This means that the airport services which handle aircraft at their points of call must ensure that the advantages accruing from this time-saving in the air are not wasted through delays in handling baggage and freight or in re-supplying aircraft.

Particular attention has been given to the question of cutting down re-fuelling time. Efforts to gain valuable minutes during intermediate landings, and thus shorten travelling time and improve operating economy, have been successful, not least through the use of extensive mechanical equipment. After careful analysis of air transport experience and consideration of local operating requirements, oil firms and fuel tank manufacturers have developed ordinary road tanker trucks into special vehicles for aircraft fuelling.

As fuel hydrant systems—underground pipes with supply points—are still not widely available at airports, use is now made of fast, manoeuvrable airport fuelling trucks, capacious special vehicles for rapid, reliable performance of this important ground service.

*

The size and design of the fuelling trucks naturally depend on the aircraft types. For the open fuelling usual with smaller aircraft, the trucks have fuelling arms through which the fuel flows into the tanks from above.

For commercial transports, of course, large vehicles are required, so that fuelling can be completed in one operation, without the truck having to refill from the airport storage depot. As a four-engine transport consumes some 330 Imp. gallons of fuel per hour, it needs around 4,000 gallons for an Atlantic flight, a total that must be pumped into the aircraft in the briefest possible time.

A vehicle which best meets this requirement is the *trailerized tank*. With its cantilever construction, it offers the considerable advantage of large capacity—4,000 to 5,500 gallons, or substantially more with trailer—and is also characterized by easy manoeuvrability. Despite its size, it can be driven right up to the aircraft.

This type of vehicle needs no filling arms, since large aircraft can be fuelled by *underwing pressure fuelling* via two hoses. In some models the hoses are carried in the back of the vehicle along with the feed pumps, in others—the majority—in a cabin behind the driver's cab. In the latter case the pump can be operated by the vehicle's accessory drive.

When not in use the hoses are wound on drums operated either by the vehicle's accessory drive or by small liquid engines. When extended, the hoses run from the fuelling truck's cabin to the underside of the wing tanks, where they are attached with an airtight connection. They are up to 100 ft. long and 2 or 2 ½ inches in diameter. As the rate of flow per hose, in the case of some modern aircraft, is from 300 to 550 gallons a minute, a whole tank truck can be emptied within a few minutes.

*

To ensure speedy operation, the fuel must be moved under constant high pressure. Regulation is provided by an automatic *pressure system for underwing fuelling*, patented by the firm of Strüver, Hamburg. Its action is similar to that of an electric socket with built-in fuse, which maintains a constant voltage up to a given amperage: an overload would be dangerous for the consumer, an underload would reduce current intensity and capacity.

The same applies to underwing fuelling with pressure and flow: if a given pressure at the hose end is exceeded, the wing tanks may be damaged. If this pressure is not reached, flow is reduced and valuable time lost. Hence a regular pressure at the hose end is of great importance. Automatic regulation is achieved through the combined action of a venturi, a control valve and an overflow valve. The pressure required is 30 or 51.5 p.s.i. depending on the aircraft type.

*

As the fuel must be measured in order to record the quantity supplied, a fuelling truck requires *counters and measuring equipment* which must be officially calibrated. In addition it must have filters to keep the fuel scrupulously clean and exclude all air, as well as valves, safety devices, switches etc., all of which, together with the pumps, pressure regulators and other equipment, form a complicated system of pipes and fittings.

All fittings are housed in a cabin which is accessible from both sides of the vehicle. On one side are the feed pump, regulating system, filters and some of the pipes, on the other the controls, measuring and checking instruments. In this way all controls can be operated by one man. Small indicators show the switch positions, and a diagram of the pipe system on the switchboard makes for easy supervision. Because of their low-set position, the dials of the flowmeters are inclined at 45° to make them more easily legible.

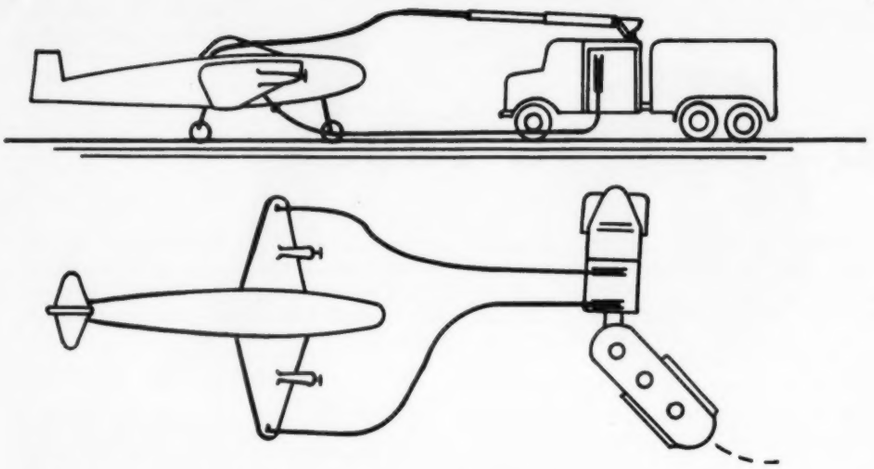
The switchboard also contains instruments to show pump pressure, pump vacuum and pressure at the hose end. For *night operations* it is electrically illuminated; in addition the vehicle frequently carries a telescopic lighting mast roughly 26 ft. high.

*

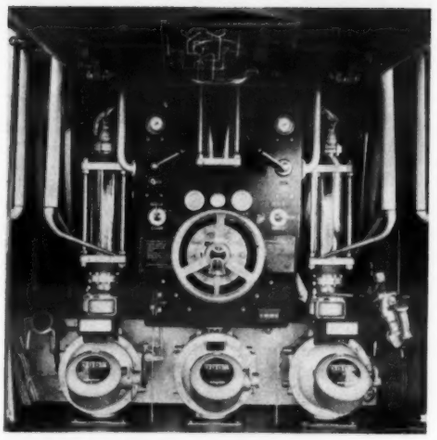
The vehicle's fuel tanks are made of *light metal*. In addition to good resistance to corrosion by fuels, this material—which is also used for a large proportion of fittings and all the pipes—has the well-known advantage of low specific weight. Hence large quantities of fuel can be transported by a relatively small tractor.

Refuelling an aircraft in 1913.

Strüver 4,000-gallon trailerized tanker truck refuelling a Vickers Viscount.



Fuelling via an arm (top) and from a trailerized truck with two hoses (bottom).



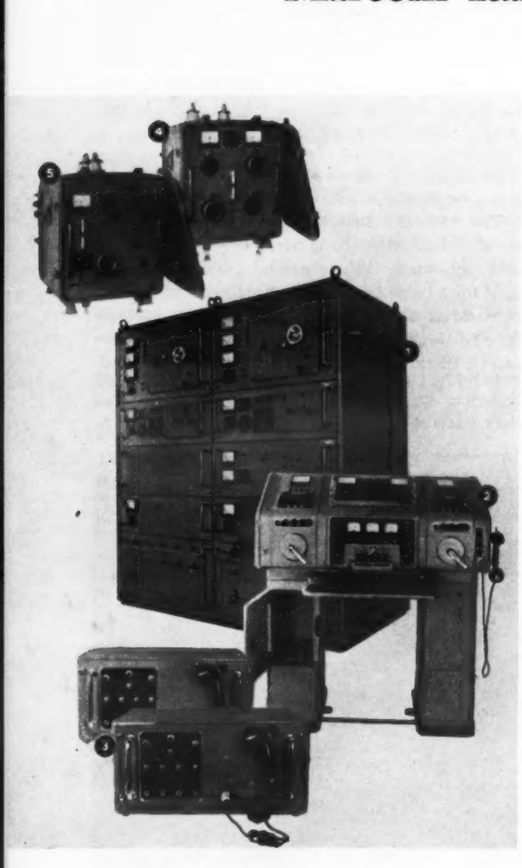
Control panel of a modern trailerized refueller.

The light metal sheet used is 0.2 or 0.24 inches thick, depending on the size of the tank, and is carefully welded; all stressed seams are checked by X-ray.

To reduce empty weight still further, the vehicles are preferably made in cantilever form, and the weight thus saved can be added to the fuel load. Another advantage of the cantilever construction is the easy accessibility of the truck bottom and the rear axle. A ladder and a catwalk facilitate access to the roof fittings; the wedge shape of the tank gives a better centre of gravity position and ensures good water separation.

A long distance has been covered since 1913, when aircraft were refuelled from open cans—as shown in the first picture—to today's highly efficient airport fuelling trucks. Though scarcely noticed by the general public, development here has been similar to that of the aircraft these vehicles serve.

Marconi Italiana Two-Channel HF Transmitter



A new two-channel transmitter of 1,000 W output power and a frequency range of 2.8 to 18 mc/s has been in service for several months in the telecommunications centres of Italy's air traffic control. Produced by Marconi Italiana S.p.A., Genoa, the equipment serves the following purposes: W/T transmission of A_1 (CW) and A_2 (MCW) waves, in the second case with and without suppression of the carrier; R/T transmission (A_3; with and without carrier suppression); W/T transmission of F_1 (with step-by-step frequency change).

The equipment has already been tested under extreme climatic conditions, including temperatures between -25^{o}C and $+50^{o}$C, atmospheric humidity up to 90%, and minimum atmospheric pressure below 450 mm Hg. To meet official specifications, it is of rugged construction, while at the same time being designed for maximum operating reliability. Margin of error in the crystal-controlled frequency stabilization under operating tolerances (temperature range as above, voltage $\pm 10\%$, grid frequency $\pm 5\%$) is only 1: 20,000.

The installation consists of the following components (cf. fig.): 1 – two transmitters; 2 – control desk; 3 – two control units with telephone connection to control desk; 4 – matching unit for the dipole aerial; 5 – matching unit for the whip aerial and the Marconi radiator, which also serves as matching unit for the coaxial cable leading in from the aerials.

The output power of each of the two transmitters (measured at 18 mc/s and 75 Ohm impedance) is approx. 1.2 kW for A_1 transmission, and approx. 1 kW (related to carrier) for A_2 and A_3. Current used is three-phase A.C. of 220/380 V and 50 c/s, with a power of 4.2 kVA for A_1 and 5.4 kVA for A_2 and A_3.

The following modulation characteristics are given by the makers: amplitude modulation range 300 to 3,000 c/s; linearity ± 1.5 db for 800 c/s tone frequency; distortion less than 6% for 90% modulation depth; automatic suppression of carrier; signal-to-noise ratio 50 db.

From the control desk the following operations can be carried out:

- separate remote operation of the two transmitters;
- operation, or keying and modulation of the two transmission channels;
- selection of the required transmission frequency;
- selection of one of the three available control crystals for the frequency used;
- operation and modulation of the receiver;
- telephone connection with the two transmitter control units;
- acoustic control of the A_2 and A_3 transmission.

In addition the two transmission sets can be combined as follows: A_1 telegraphy on both transmitters, when the latter are not provided with modulation equipment; A_2 telegraphy and A_3 telephony on both transmitters, when they are provided with modulation equipment; F_1 telegraphy on both transmitters, using two exciter equipments; use of either of the two matching units with either of the two transmitters.

Book Reviews

Einführung in die technische Thermodynamik und die Grundlagen der chemischen Thermodynamik. — By Prof. Dr.-Ing. Ernst Schmidt. — Springer-Verlag, Berlin/Göttingen/Heidelberg, 1956 (German ; 522 pages ; 244 illustrations and 69 tables ; three vapour diagrams ; price DM 30).

The present textbook (sixth edition) is based on a series of lectures read by the author at the Danzig, Brunswick and Munich Institutes of Technology and describes the foundations of thermodynamics and its classical applications. In particular, new light is thrown from various sides on the second main proposition in the theory of heat, which experience has shown to be frequently difficult to grasp. The chapter on fluid flow machines and the thermodynamics of rocket propulsion has been rewritten. Of particular interest is the section on " Rocket propellants and their evaluation ", with tabularized data on the qualities of liquid oxygenizers, fuels and explosives. The last sections contain an outline of chemical thermodynamics with special reference to combustion processes.

A special feature of the new edition is that, although the usual system of technical measures (metres, seconds and kilogrammes of power) is retained, the transition to the Giorgi system (metres, seconds, kilogrammes of mass, ampères and Kelvin degrees) recommended for international introduction at the Ninth General Conference for Weights and Measures in 1948, is prepared by extensive quotation of conversion factors. The main text is supplemented by 69 tables, a list of symbols used, vapour tables (including Mollier diagrams for water vapour, ammoniac and damp air), sample problems, bibliography, index of names and subject index. Ba.

Fundamentals of Vibration Analysis. — By N. O. Myklestad. McGraw-Hill Book Company, Inc., New York and London, 1956 (English ; 260 pages ; price $6.50 or 49 shillings).

The author, Head of the Stress, Vibration and Gear Group of AiResearch Manufacturing Company of Arizona, addresses this book primarily to readers wishing to study the fundamental principles of vibration processes. — Passing from vibration systems with a single degree of freedom to those with several degrees, the book leads finally to a number of new features of presentation. Examples and problems at the end of each chapter and their solutions at the end of the book demonstrate the applicability of the methods described and help to increase understanding of this complex subject. Re.

The Selected Works on Wing Theory of Sergei A. Chaplygin. Translated from the Russian by Maurice A. Garbell. — Published by the Garbell Research Foundation, San Francisco, 1956 (English ; 97 pages).

The extensive writings of Sergei Alekseevich Chaplygin, Russian aerodynamicist and pupil of Joukovsky, have been largely unknown to the Western world. In 1949 his most important writings were published by the Soviet Government Publishing House for Technical and Theoretical Literature under the title " Izbrannye Raboty po Teorii Kryla " (" Selected Works on Wing Theory "). The present extremely careful translation now gives aerodynamicists the opportunity to acquaint themselves with the work of this leading Russian scientist, who, working alongside Joukovsky in the first decade of the century, established the fact that airfoils should have a rounded leading edge and a sharp trailing edge. Re.

Selected Combustion Problems, II — Transport Phenomena ; Ignition ; Altitude Behaviour and Scaling of Aeroengines. Conference report on the Combustion Colloqium held by N.A.T.O.'s Advisory Group for Aeronautical Research and Development at Liège, Belgium, from December 5th to 9th, 1955. — Butterworths Scientific Publications Ltd., London, and Interscience Publishers Inc., New York, 1956 (English and French ; 495 pages ; price 90 shillings or $12.50).

Not long after the first AGARD combustion colloquium in Cambridge, England, in December 1953, it was decided to hold a second colloquium in 1955 to deal with the questions unanswered at the first and to assemble the extensive results of research. The reports now published on the meeting in Liège give a comprehensive survey of present knowledge and of experimental methods in the field of combustion research. More than twenty scientists read papers on questions of present interest, including combustion processes at high altitudes, optimum dimensions for rocket burners etc. Each of the five main chapters is supplemented by an account of the discussion following the papers, revealing not only the difficulties facing modern aeronautical research but also how fruitful international cooperation, such as practised by AGARD, can be. Re.

Rocket Propulsion Elements (second edition). — By George P. Sutton. — John Wiley & Sons, Inc., New York, and Chapman & Hall, Ltd., London, 1956 (English ; 383 pages ; price $10.25).

The author, a senior employee of Rocketdyne, a division of North American Aviation, Inc., and an instructor at the University of California, was awarded the American Rocket Society's G. Edward Pendray Award in 1951 for the first edition of his book " Rocket Propulsion Elements ". Strengthened in his original purpose by the success of the book, he decided to publish a second, considerably enlarged edition, which would also do justice to the growing importance of solid-propellant rockets and their propellants. Another new addition is a chapter on heat transfer, dealing with the thermal limits to the operation of rocket motors. With its supplement of problems and bibliography covering roughly 650 sources, this introduction to rocket engineering should be of value to both students and practical engineers. Re.

Flugmedizin. — By Dr. med. Bruno Müller. Volume 34 in the series of transport publications issued by the North Rhine-Westphalia Ministry of Economy and Transport, Düsseldorf, 1956 (German ; 231 pages ; price DM 6).

The enforced break in German aviation activities during the first ten years after the war explains why German aeronautical medicine has no present need for literature on special fields, but first a comprehensive, clearly written outline of recent developments in the branch as a whole. An excellent survey of this kind is provided by the present book. The author, who began his teaching career in 1934/35 at a German university clinic and in 1954 had the opportunity to visit the best-known aeronautical medical research centres in the United States, is not only a doctor. He has been a glider pilot since 1927 and obtained his A2 pilot's licence for powered aircraft in 1933. He studied the physical effects of acceleration in his own Klemm 25 aircraft.

In other words, the author addresses his book not only to medical officers, but also to engineers, military, commercial and test pilots, to all who have to consider the human factor in aviation. The following are the chapter headings : High Altitude Flight and High Altitude Effects ; Acceleration and Centrifugal Effect ; Air Sickness ; Sensory Organs and Sensory Illusions in Flight ; The Psychophysiology of Flyers ; Flight Hygiene : Flying Accidents ; Flying Fitness ; Problems of Space Medicine. He.

Aircraft Engines of the World 1956. — By Paul H. Wilkinson. — Published by Paul H. Wilkinson, New York, 1956 (English ; 320 pages).

More than 30 new engines are included in the 1956 edition of this unique engine reference book. An introductory chapter on the activity of the major engine manufacturers is followed, as in earlier editions, by a description of the engines of all countries engaging in engine manufacture, divided into two parts : gas turbines and rocket motors, and piston engines. All data given are those available last spring. New information includes, for example, first details of the United States' Westinghouse J-54 turbojet and the Russian Mikulin Mik-209 jet. The book is rounded off with a chapter on engine accessories, details of the most commonly used fuels and lubricants and tables of the most important military aircraft and their power plants. Re.

The Legal Status of Aircraft. — By J. P. Honig. Martinus Nijhoff, The Hague, 1956 (English ; 214 pages ; price 12.50 guilders).

What civil and criminal laws are applicable on board aircraft ? What country has legal jurisdiction over occupants of an aircraft ? What rights can be recognized in aircraft ? These questions have been occupying air law experts since the early days of flying, but no satisfactory solutions have yet been found. The present study, published by the well-known Dutch law publishers of Nijhoff, comes at an opportune moment. The I.C.A.O. Legal Committee is now preparing the bases for a future convention on the legal status of aircraft. The author introduces the reader, in admirably clear fashion, to all the elements of national legislation and international law which must be taken into consideration in any future clarification of these problems. He.

Technical Aspects of Air Transport Management. — By R. Dixon Speas. — McGraw-Hill Book Company, Inc., New York, Toronto, London, 1955 (English ; 316 pages ; price $8.50 or 64 shillings).

Many commercial airline employees are insufficiently acquainted with the technical side of air transport operation. This deficiency can have undesirable repercussions on cost control. The present book introduces the non-technical reader in clear, easily assimilable manner to all operating problems and shows the close connection between efficient equipment, expert maintenance and a credit balance. At the same time the non-technical aspects of airline management are by no means ignored. A valuable aid in the training of air transport personnel. He.

Administration, Vol. 3, No. 4, Special issue on " Civil Aviation in Ireland ". Castle Publications, Dublin, 1946 (English ; 126 pages).

This special issue of the Irish quarterly review " Administration " gives an unusually full picture of Irish air transport. Selected articles : " Making an Airline Pay " by J. F. Dempsey, General Manager, Aer Lingus ; " Technically Speaking " by Captain J. C. Kelly-Rogers, Deputy General Manager, Aer Lingus ; " Public Relations " by David Hayes, Public Relations Officer, Aer Lingus. He.

Books received

Publications scientifiques et techniques du Ministère de l'air. — Distributed by the Service de documentation et d'information technique de l'aéronautique, Paris.

No. N. T. 58 : *Sur un curieux cas d'alternance de tourbillons*, by Edmond A. Brun, Louis Castel and Dieter Faulmann.

No. N. T. 60 : *Etude expérimentale de la convection forcée de la chaleur à partir de cylindres à surface rugueuse*, by Edmond A. Brun, Giovanni Brunello and Magdeleine Vernotte.

No. 309 : *Nouvelle méthode approchée de calcul des couches limites laminaires et turbulents en écoulement compressible*, by Alfred Walz.

No. 310 : *Etude de la lubrification sous pression rapidement variable*, by Fernand Charron.

No. 311 : *Diffusion centrale des rayons X par les métaux*, by Jean Blin.

No. 312 : *Etude expérimentale de la convection forcée sur paroi mobile* (Hyperconvection Favre), by Charles Bory.

No. 313 : *Utilisation des compteurs de Geiger-Müller à l'étude de variations de texture de laminage suivant la température de déformation*, by Francis Provost.

No. 314 : *Sur la turbulence spatialement homogène d'un fluide compressible*, by Maria Z. Krzywoblocki.

No. 315 : *Contribution à l'étude des phénomènes de durcissement dans l'alliage aluminium-cuivre à 4% de cuivre*, by René Graf.

*

Reports of the Deutsche Versuchsanstalt für Luftfahrt ; issued by the DVL Zentrale für Wissenschaftliches Berichtswesen, Mülheim, Ruhr ; published by Westdeutscher Verlag, Cologne and Opladen, 1956 :

Report No. 6 — *Spannungsoptische Untersuchungen von Turbinenschaufelfüssen (Stand 1953).* — By K. Leist, K. Schleiermacher and J. Weber (price DM 14.60).

Report No. 8 — *Zusammenfassende Darstellung und Erweiterung des Aequivalenzsatzes für schallnahe Strömung*, by F. Keune (price DM 17.90).

Report No. 13 — *Der gewölbte und verwundene Tragflügel ohne Dicke in Schallnähe*, by F. Keune (price DM 9.25).

Report No. 16 — *Über die Beulung anisotroper Plattenstreifen*, by W. Thielemann (price DM 15.40).

Report No. 17 — *Beitrag zur Frage der Beulung dünnwandiger axial gedrückter Kreiszylinder*, by W. Thielemann and H. J. Dreyer (price DM 7.40).

Research reports of the North Rhine-Westphalia Ministry of Economy and Transport ; published by Westdeutscher Verlag, Cologne and Opladen :

Report No. 158 — *Ein Beitrag zum Problem der Spannungskorrosion bei Pressprofilen und Pressteilen aus Aluminium-Legierungen.* — By Dipl.-Ing. W. Rosenkranz (price DM 27.40).

No. 191 — *Schwingungsverhalten eines Schaufelkranzes im Vakuum*, by Dr.-Ing. H. Söhngen.

No. 198 — *Zur Aerodynamik des Ringflügels. Die Druckverteilung dünner, fast drehsymmetrischer Flügel in Unterschallströmung*, by Prof. Dr. rer. nat. J. Weissinger.

Report No. 201 — *Die Sicherheit im Luftverkehr.* — By E. W. Pleines (price DM 39.45).

Report No. 214 — *Berechnung der optimalen Leistungen, Kraftstoffverbräuche und Wirkungsgrade von Einkreis-Strahltriebwerken am Boden und in der Höhe bei Fluggeschwindigkeiten von 0-2,000 km/h.* — By Dr.-Ing. J. Endres, Messerschmitt, Rhineland (price DM 15.40).

No. 218 — *Bericht über eine Theorie der Strömung um Rotationskörper ohne Anstellung bei Machzahl Eins*, by Dr. rer. nat. F. Keune.

No. 247 — *Strömung vor einem Überschall-Laufrad*, by Dr. rer. nat. H. Söhngen.

No. 255 — *Strömung von Flüssigkeiten mit temperaturabhängiger Zähigkeit (Kühlung von Ölen)*, by Ing. B. v. Schlippe.

No. 256 — *Die Strömung einer Quellstrecke im Halbraum — eine strenge Lösung der Navier-Stokes-Gleichungen*, by Prof. Dr. Phil. C. Schmieden and Dipl. Math. K. H. Müller.

No. 281 — *Der Messwagen des Instituts für Maschinen-Dynamik der deutschen Versuchsanstalt für Luftfahrt, Aachen*, by Prof. Dr.-Ing. Karl Lürenbaum.

Die Grenzen der Schlechtwetter-Landetechnik und ihre Auswirkung auf den Luftverkehr, by Dr.-Ing. Hans J. Zetzmann. Technical and Economic Report of the North Rhine-Westphalia Ministry of Economy and Transport. — Manuscript 1955.

Die Verkehrsentwicklung des Landes Nordhein-Westfalen. Jahresbericht 1955. — Report No. 27 of the North Rhine-Westphalia Minister of Economy and Transport in the «Verkehrsbeobachtung » series.

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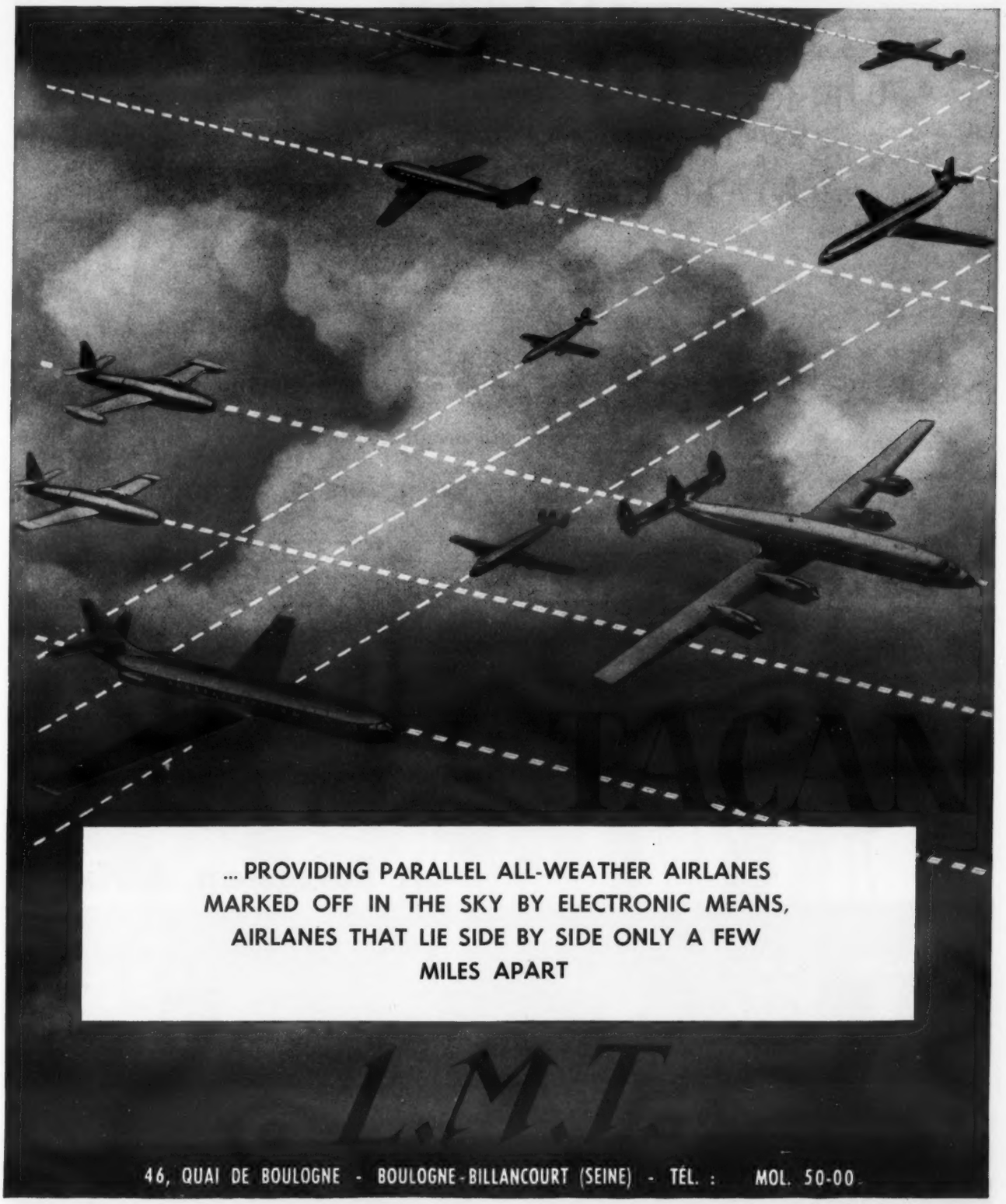

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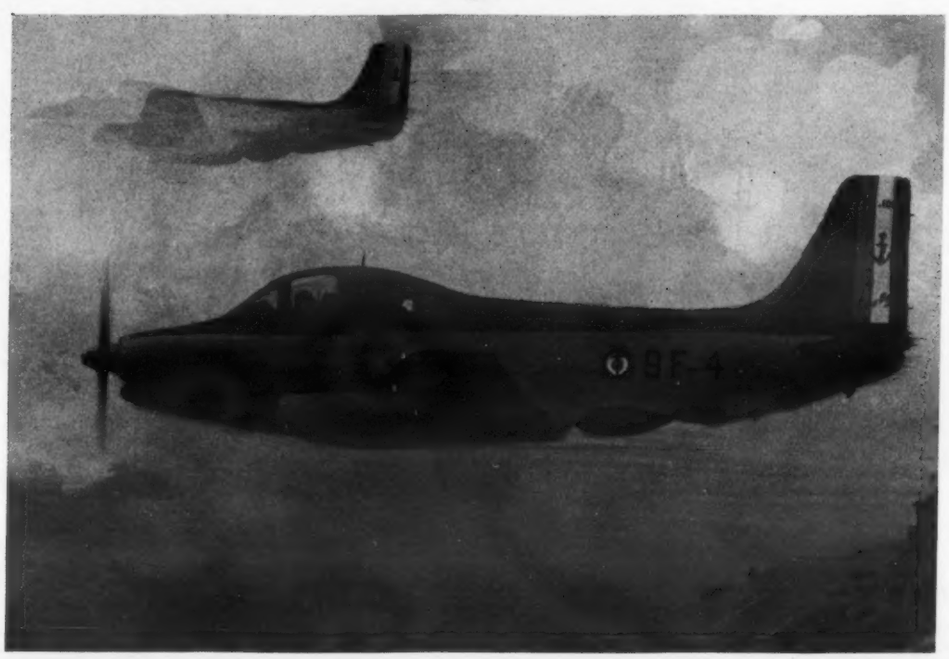

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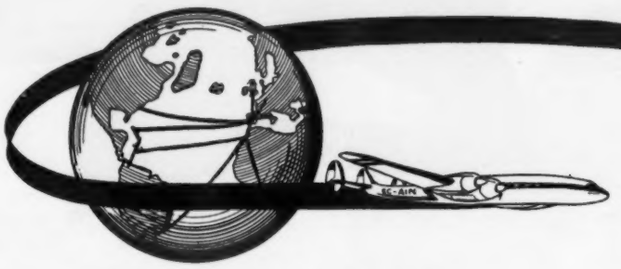

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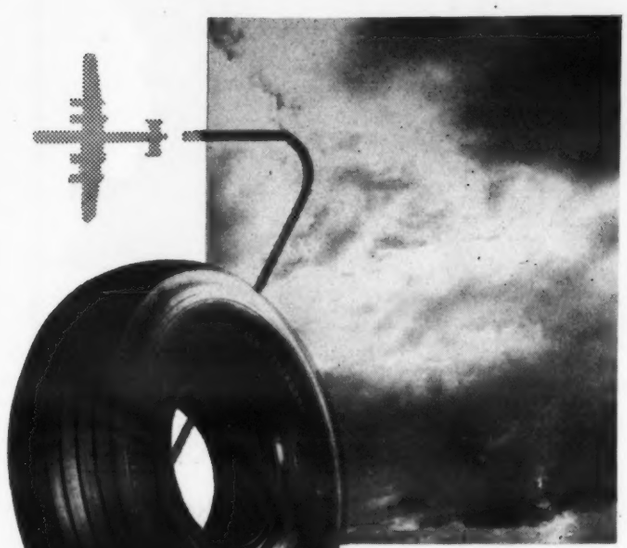

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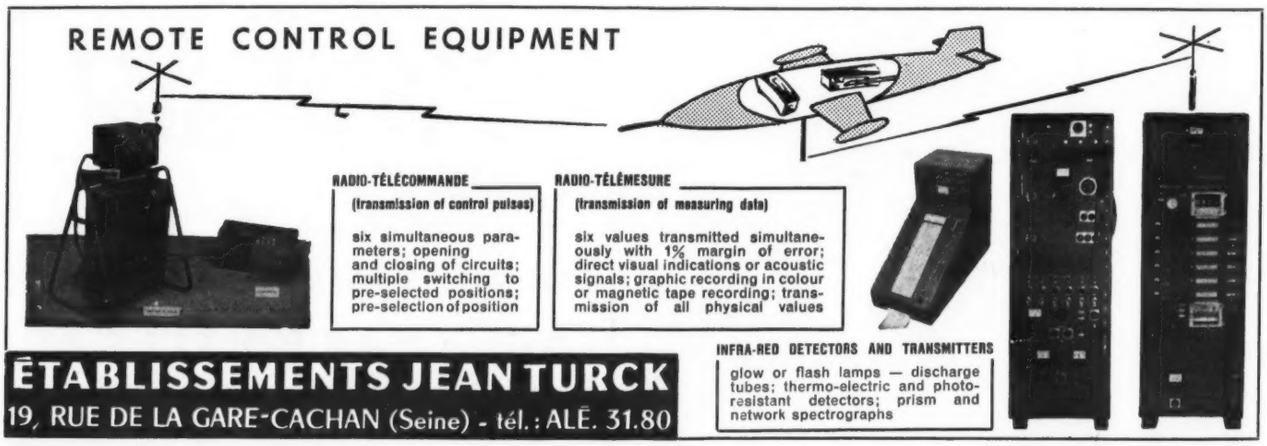

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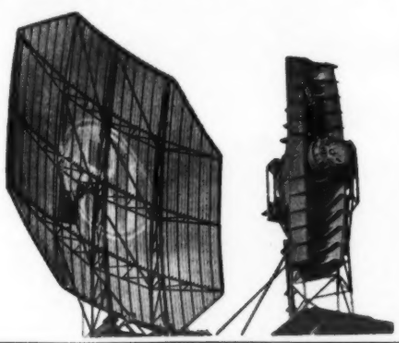

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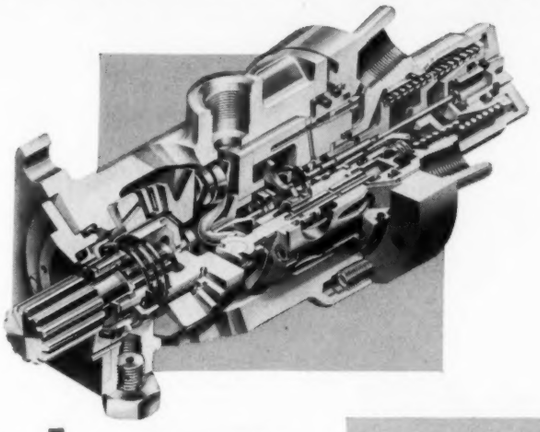

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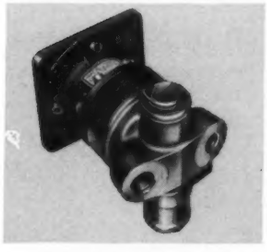

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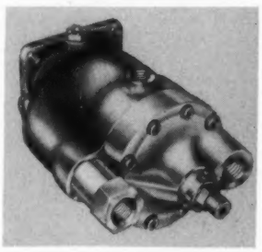

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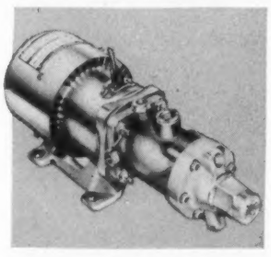

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